Jörn Thiede

Gas and Water Seepage on the Continental Margin: SEEP

Contract Number: MAS2-CT92-0040

Annual Report 1993

E. Suess

Co-ordinating Institution: **GEOMAR, Germany**

Partner Institutions:
Marine Biological Association, U.K.
British Geological Survey, U.K.
University of Hamburg, Germany
Institute of Marine Biology, Greece

ANNUAL REPORT ON CONTRACT MAS2-CT92-0040

Gas and Water Seepage on the Continental Margin: SEEP

MANAGEMENT REPORT

GEOMAR - Research Center of Marine Geosciences

E. Suess (Co-ordinator)

The R.V. METEOR cruise was the focus of the first year of the SEEP-contract. A planning meeting was held in Kiel prior to the cruise. The field work from 28 September - 25 October 1993 centered on four potential seep sites: the Skagerrak, the Faeroe-Shetland channel, the Barents Sea slope and the Barents Sea crater field. With the exception of the Faeroe-Shetland channel, all areas showed evidence for fluid and gas escape. Progress with the contract overall was good, although adverse weather conditions during the cruise prevented data acquisition to be truely excellent. The **cruise report** is completed and will be published in April 1994. In addition all partners have received a compendium of data collected during the cruise.

Work-up of cruise data and samples will be the focus for the second year of the contract. During the spring of 1994 a workshop is planned to exchange results and prepare outlines of manuscripts for publication. Tentatively, the seep site in the Skagerrak, located at and around the METEOR Station 464-1, should yield sufficiently interesting data to form the basis for one publication. The Barents Sea craters, their relationship to the bedrock structure, and dating of the "explosive event" should provide data for a second publication.

Several task which were not fully accomplished during the R.V. METEOR cruise will receive high priority in the second year. These include *in situ* sampling by VESP coupled with continuous flow measurements and a more complete collection of macro- and meio-fauna from actively flowing seeps. Such a location is available in the western Baltic Sea off Eckernförde located within an hour's steaming time from Geomar at Kiel. This site is well-suited for deploying VESP and obtaining data on the carbon and sulfur cycling. Macro- and meio-vent fauna so far has not been found at this site. Therefore, the participation of partners separately in other cruises, scheduled to the Skagerrak seep site, is presently being pursued.

PROGRESS WITH INDIVIDUAL TASKS

I. Field work

1. *Map seep areas and define the geological setting and likely origin of the seeps:* Data collection completed, evaluation in progress.

1.1 *Hydrosweep bathymetry:* Was performed on Cruise M26/2 of RV METEOR.

1.2. *Sub-bottom profiling:* Was performed on Cruise M26/2 of RV METEOR.

1.3 *Side scan sonar:* Was performed on Cruise M26/2 of RV METEOR.

1.4 *Geological sampling:* Was undertaken on Cruise M26/2 of RV METEOR

1.5 *Video images & survey:* Were undertaken on Cruise M26/2 of RV METEOR in the Barents Sea.

2. *Determine the source and distribution of the gas and fluids released at each site and establish the chemical gradients associated with seepage:* Methane gradients were determined on Cruise M26/2 of RV METEOR.

2.1 *Synthesis of existing data on structural geology and stratigraphy of target areas:* In Progress

2.2 *Geochemical and biochemical tracers, isotopic criteria and distribution of gases in sediments, pore water and seep fluids:* Measurements and sample collection was done on Cruise M26/2 of RV METEOR.

2.3 *Age dating of active sites:* In progress

3. *Compare the physical and geotechnical properties of sediments at the seep sites with those from the surrounding area and assess the relevance of these factors for the presence of submarine mud slides:* existing sample collection inadequate

3.1 *Sediment description & radiography:* Sediment description in cruise report; no radiography

3.2 *Water content, wet and dry bulk density, porosity:* Water content performed.

3.3 *Shear strength:* Not performed

II. Direct fluid flow measurements

4. *Quantify the fluid and geochemical mass fluxes using an in situ device deployed from a surface vessel via a lander system:* No adequate sampling sites found.

4.1 *Modification of existing device including installation of flow sensor:* Modification completed.

4.2 *Integration of video, sampling and lander system:* Integration completed.

4.3 *Testing and field operation:* System was tested sucessfully on a Cruise of RV ALKOR in the Baltic and operated on Cuise M26/2 of RV METEOR in the Barents Sea.

4.4 *Deployment at active sites:* No suitable and active sites for deployment were found on Cruise M26/2 of RV METEOR.

III. Biogeochemical cycling and adaptation of vent fauna

5. *Determine sulphur and carbon cycling at different horizons in sediment cores from seep and non-seep sites:* Samples for these studies were taken on Cruise M26/2 of RV METEOR.

5.1 *Sulphur cycle: sulphur compounds and sulphate reduction rates:* Sufphate reduction rate incubations were performed and samples were prepared for the analysis of the sulphur compound.

5.2 *Rates of methane oxidation and methanogenesis:* Not performed.

5.3 *Carbon cycle: Methane and $\sum CO_2$ and their isotopic criteria:* Samples collected; analyses in progress.

6. *Compare the species composition, density and distribution of benthic fauna at seep sites with that in the surrounding sediments unaffected by seepage:* In progress.

6.1 *Sample collection and species identification across chemical gradients:* Samples were collected on Cruise M26/2 of RV METEOR and species will be identified.

6.2 *Enumerate the macrofauna and determine their biomass:* In progress.

7. *Examine the structural and ecological adaptations of organisms living in seep areas with reference to the physical and chemical environment of the seeps:* In progress.

7.1 *Collection of animals across chemical gradients and technical preparation for electron microscopy:* Completed.

7.2 *Ultra-structure and histochemistry of animal tissue:* In progress.

8. *Determine the role of symbiotic chemoautolithotrophic and methylotrophic bacteria in benthic production at seep and non-seep sites:* Limited samples available, analysis not yet performed.

8.1 *Identification of chemoautotrophic and methanotrophic symbionts:* Limited samples, analysis not yet performed.

8.2 *Methane-carbon in animal tissue by ^{14}C activity:* Questionable because of inadequate samples.

IV. Management & Operation

9. *Integrate results and determine milestones:* Cruise report and outline of manuscripts.

10. *Organise cruise and field work:* Planning of workshop and supporting field work and experiments (Mittelgrund, Eckernförde Bay or alternatively participate in Skagerrak cruise as guest investigator).

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Authors:

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E Suess (Co-ordinator), R Windoffer

CONTENTS

OVERVIEW OF SCIENTIFIC AND TECHNICAL PROGRESS

By E Suess, GEOMAR Kiel

The R.V. METEOR Cruise 26-2 from 28 September - 25 October 1993, was the focus of the first year of the SEEP-contract. Progress with the contract overall was good, although adverse weather conditions during that cruise prevented data acquisition to be truely excellent, which it would have been otherwise. All partners participated and were able to collect sufficient samples. Work centered on four potential seep sites: the Skagerrak, the Faeroe-Shetland channel, the Barents Sea slope and the Barents Sea crater field on the inner shelf (Fig. 1). All areas, with the exception of the Faeroe-Shetland channel, showed evidence for fluid and gas escape, although not as vigorously as hoped.

The Skagerrak survey and sampling (Fig. 2) established that a previously known seep locality is part of linear trend parallel to the outer shelf. The criteria for detecting active seeps were by enhanced subsurface reflectors below topographic ridges in the parasound survey and methane-anomalies in the bottom water. Strong evidence for lateral flow as well as vigorous methane oxidation was gleaned from pore water chemistry and biochemical data in near-surface sediments. Known seep organisms, adult pogonophoras and larvae and thyasirid bivalves, were collected for biochemical and microstructural analyses. Video- and side scan sonar images did not detect seep localities in the Skagerrak area, probably due to their transient nature affected by the shifting sands.

Deep-tow boomer data, methane distribution in the water column, geological and biological sampling from the Faeroe-Shetland channel (Fig. 3) target all showed that the structural features previously thought to be related to seepage, actually are current-shaped sigmoidal drift bodies of coarse sediment which form along the bottom of the channel. No geophysical evidence for gas hydrates were found. This target should no longer be considered a seep site.

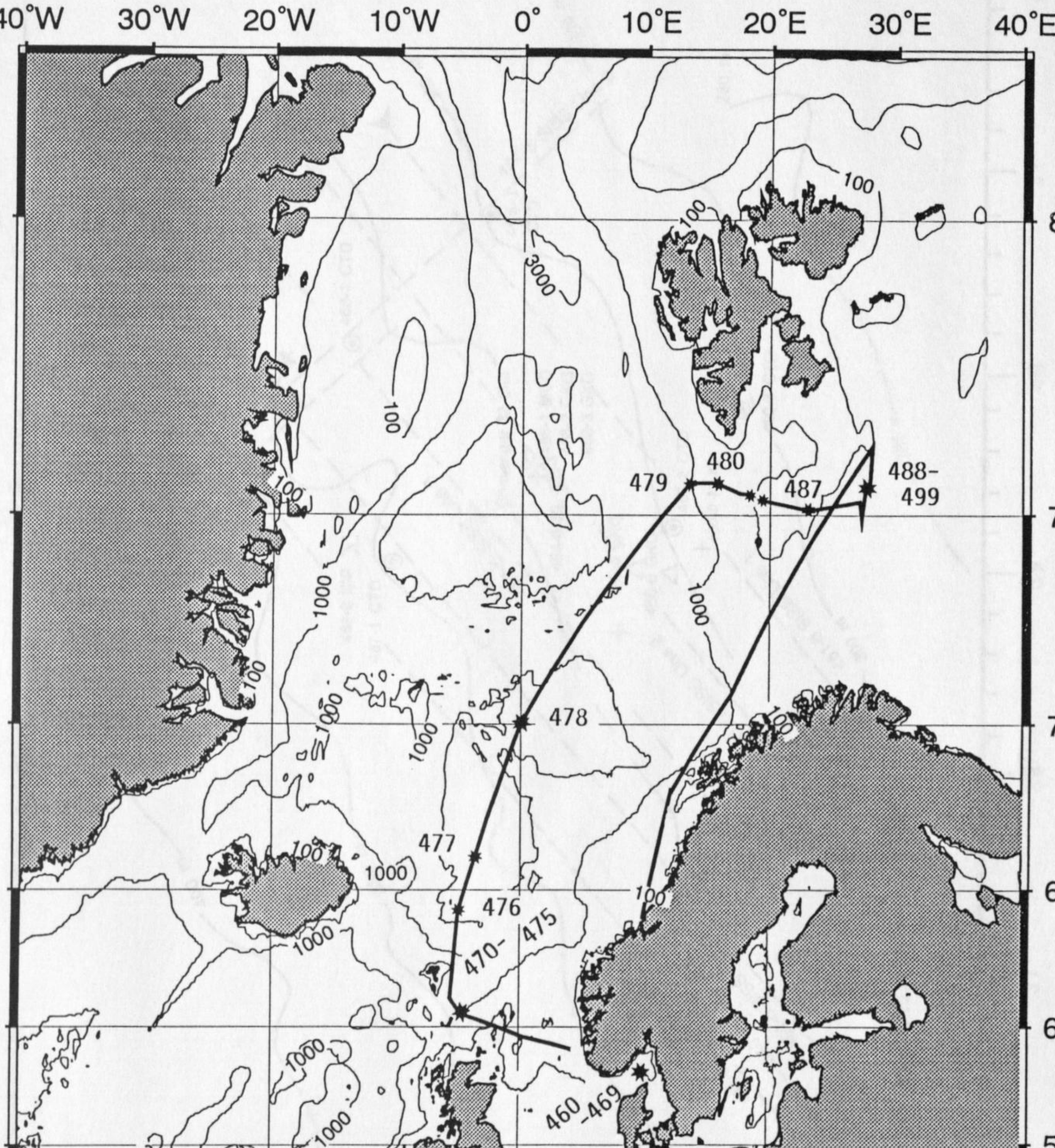


Fig. 1: Cruise track and stations during R.V. METEOR Cruise 26/2; SEEP-objectives were pursued at stations 460-469 (Skagerrak), 470-475 (Faeroe-Shetland Channel), 480 (Barents Sea slope), and 488-499 (Barents Sea crater field).

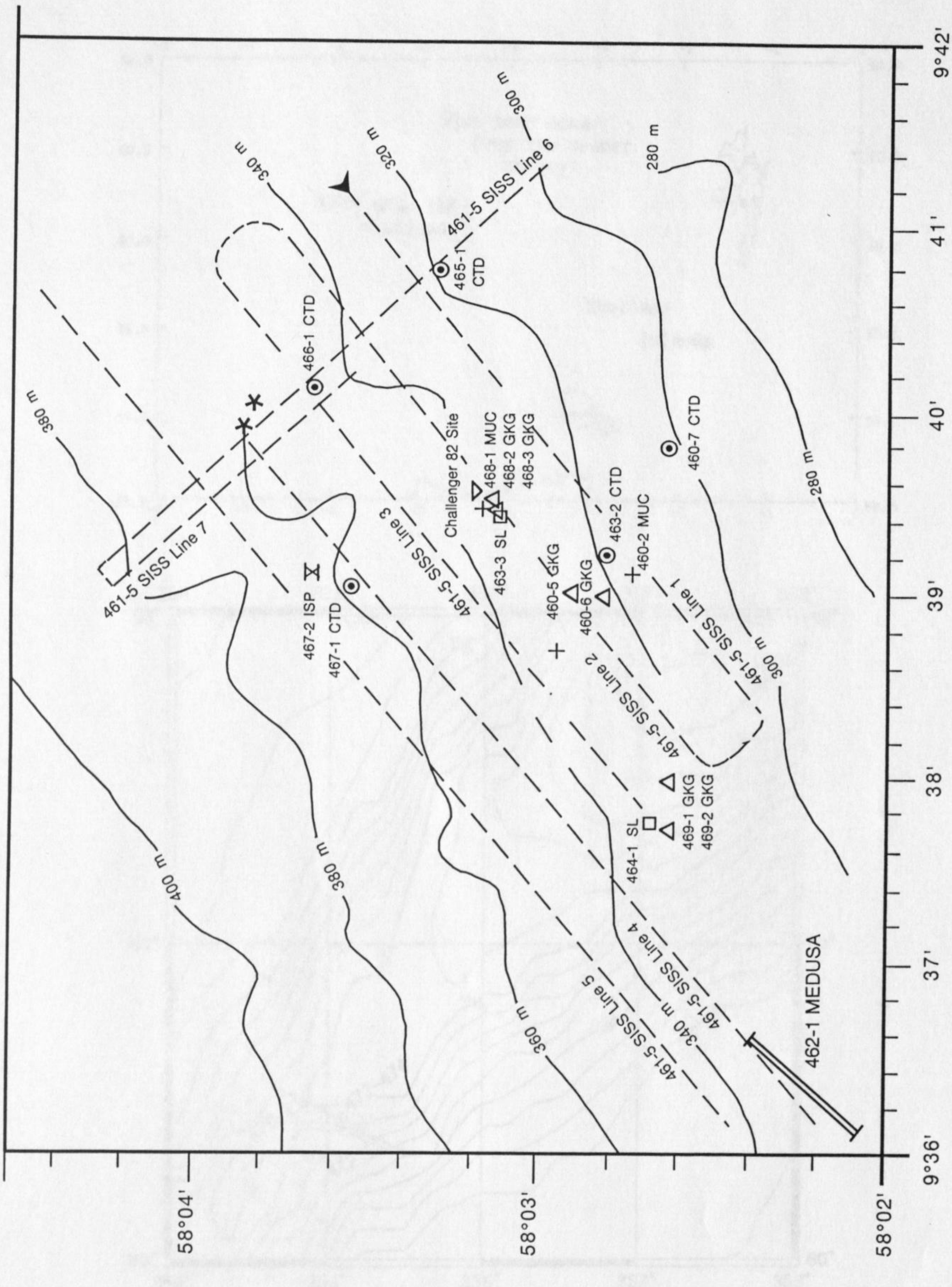
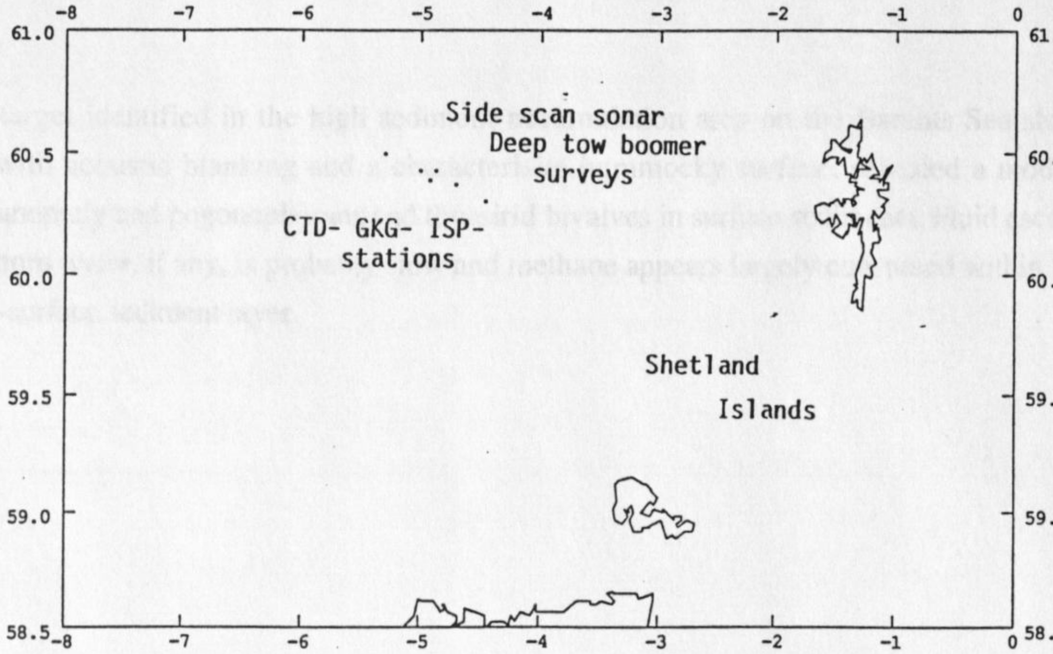


Fig. 2: Skagerrak sampling sites and survey lines; SISS = Side scan sonar, CTD = hydrographic station, GKG = Box core sites, MUC = Multicorer sites, ISP = in situ pump, SL = Gravity corer site, MEDUSA = in situ methane detection survey; *ship wreck site located 1991 and 1993 (R.V. METEOR); — R.V. CHALLENGER seep site.



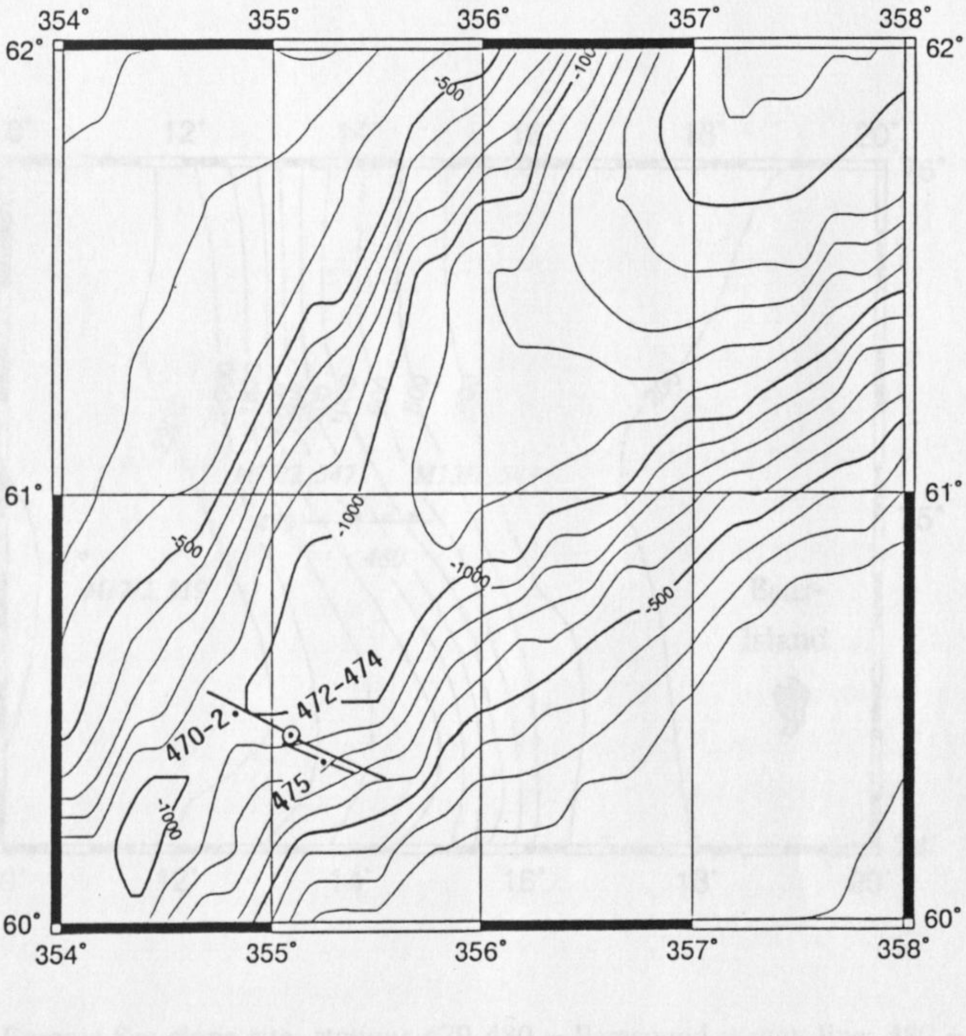


Fig. 3: Faeroe-Shetland channel sampling and survey area; the long line = SISS survey, the short line = DTBS (deep-tow boomer system); Station 470-2 = CTD and CH_4 cast; 475 = box core sampling site; 472-474 = geological sampling of sediment drift body.

A small target identified in the high sediment accumulation area on the Barents Sea slope (Fig. 4) with acoustic blanking and a characterisitc hummocky surface, revealed a modest methane anomaly and pogonophorans and thyasirid bivalves in surface sediments. Fluid escape to the bottom water, if any, is probably slow and methane appears largely consumed within the oxic near-surface sediment layer.

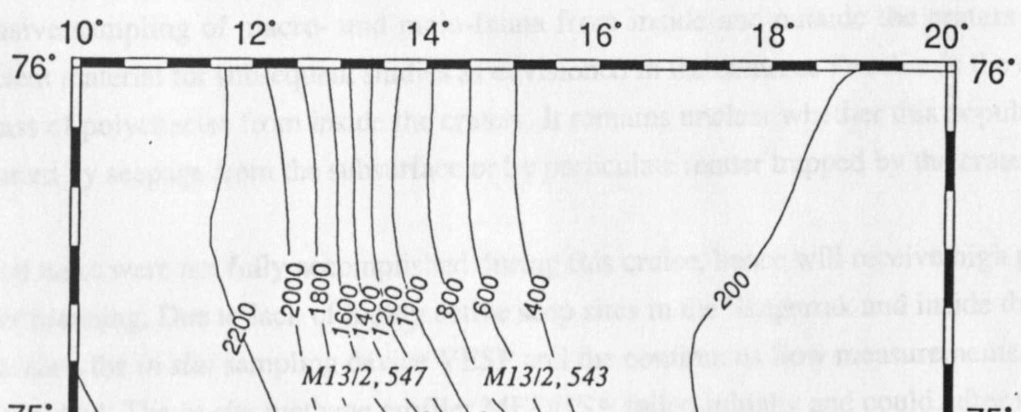


Fig. 4: Barents Sea slope site; stations 479-480 = Parasound survey line; 480 = coring station; also shown are coring and hydrocast stations from previous cruises (M13, 1990 and M17, 1991).

The existing survey of the crater field on the Barents Sea shelf was extented to the west with several additional craters identified (Fig. 5). The craters follow closely two structural trends (strike 60° and 120°) and they appear to be quite young explosive features blasted from a lithified bedrock of high acoustic velocity. The subsurface of some of the craters shows enhanced reflectors and "bright spots" indicating gas accumulations, although there did not appear to be a difference in methane in the water column above the craters nor in the abundance of benthic organisms inside the craters. A video-survey with the VESP *in situ* sampler revealed abundant chaotic lithic debris and angular clasts inside the craters giving the vivid impression that they must have formed recently under enormous force. A thin veneer of post-glacial sediment, which was sampled along with the bedrock lithologies, should be dated to yield information on the time frame of this event.

The entire area of the crater field and beyond shows a 50 m thick bottom water layer of distinctly low temperature (-0.15°C) and high methane contents. This plume appears to be very extensive, larger than the survey area, its site of origin remains unclear but the methane signal indicates a source further to the north. Methane might be used as transient water mass tracer. Extensive sampling of macro- und meio-fauna from inside and outside the craters provided sufficient material for subsequent studies as envisioned in the contract. Peculiar is the enormous biomass of polychaetes from inside the craters. It remains unclear whether this populations are supported by seepage from the subsurface or by particulate matter trapped by the craters.

Several tasks were not fully accomplished during this cruise, hence will receive high priority in further planning. Due to lack of highly active seep sites in the Skagerrak and inside the Barents Sea craters, the *in situ* sampling device VESP and the continuous flow measurements could not be completed. The *in situ* methane profiler MEDUSA failed initially and could, after successful repairs, not be deployed again under the worsening weather conditions without endangering personnel. A more intensive search for vigorously flowing seeps might have brought better success, however, the weather did not permit more surveying time. For the same reason, only a minimum of seep organisms were collected for studying their characteristic community structure and adaptations. These collections should be supplemented in the future. The anticipated gas hydrates occurrence on either side of the Faeroe-Shetland channel was not found, hence their role in sediment stability could not be evaluated. Instead, new geophysical aspects became apparent with the structural controle of the Barents Sea crater field, dating of the "explosive event", and the velocity contrast and structure of the bedrock. These aspects will be developed by the detailed analyses of the field data.

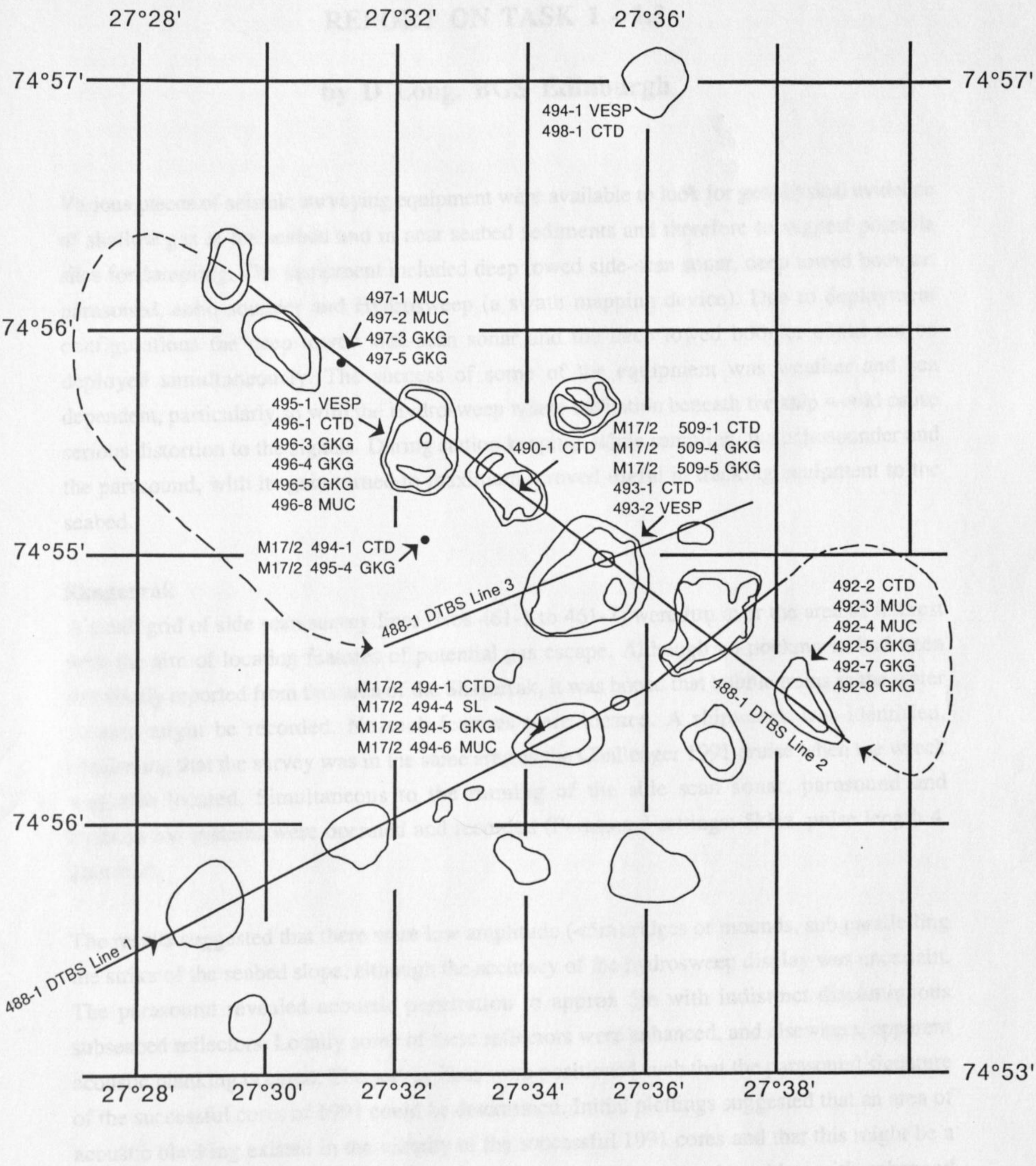


Fig. 5: Sampling and surveying the Barents Sea crater field; DTBS = deep-tow boomer lines; several craters were extensively sampled (492, 493 and 496), others were sampled during a previous cruise (M17/2, 494 and M17/2, 509); 497 represents a reference site on the shelf floor; VESP = in situ benthic chamber was deployed and yielded video-images for the first time from inside three craters. This map is not a bathymetric map but only shows the position and out-line of the craters.

REPORT ON TASK 1 - 1.3

by D Long, BGS Edinburgh

Various pieces of seismic surveying equipment were available to look for geophysical evidence of shallow gas at the seabed and in near seabed sediments and therefore to suggest possible sites for sampling. The equipment included deep towed side-scan sonar, deep towed boomer, parasound, echo sounder and Hydrosweep (a swath mapping device). Due to deployment configurations the deep towed side-scan sonar and the deep towed boomer could not be deployed simultaneously. The success of some of the equipment was weather and sea dependent, particularly so with the Hydrosweep where cavitation beneath the ship would cause serious distortion to the signals. During station keeping while sampling, the echosounder and the parasound, with its gain turned to maximum, proved useful in tracking equipment to the seabed.

Skagerrak

A small grid of side scan survey lines (Nos 461-1 to 461-7) were run over the area of interest with the aim of locating features of potential gas escape. Although no pockmarks had been previously reported from this area of the Skagerrak, it was hoped that bubble trains in the water column might be recorded. No such features were located. A shipwreck was identified, confirming that the survey was in the same area as the Challenger 1991 cruise when the wreck was also located. Simultaneous to the running of the side scan sonar, parasound and hydrosweep systems were operated and recorded (Parasound settings: 5kHz, pulse length 4, gain 6.0).

The results suggested that there were low amplitude (<5m) ridges or mounds, sub parallelling the strike of the seabed slope, although the accuracy of the hydrosweep display was uncertain. The parasound revealed acoustic penetration to approx 5m with indistinct discontinuous subseabed reflectors. Locally some of these reflectors were enhanced, and elsewhere, apparent acoustic blanking occured. The survey lines were positioned such that the parasound signature of the successful cores of 1991 could be determined. Initial plottings suggested that an area of acoustic blanking existed in the vicinity of the successful 1991 cores and that this might be a diagnostic parasound signature. It occured at the peak of a mound or ridge with enhanced reflectors beneath the slope on either side of the mound. A single core (Sta. 463-3) placed in this area was not successful in locating a seep. A second site chosen in an area of enhanced reflectors beneath a mound (Fig. 6) proved more successful in locating a methane seep (Sta.

464-1). The 1991 cruise proved that the distribution of seeps was extremely localized, so no inference is drawn on the absence of a seep from the area of apparent gas blanking. It was noted that whilst the ship was stooging about a site during the deployment of equipment, the parasound reflectors, particularly the enhanced reflectors were discontinuous indicating the limited spatial extent of the physical features which cause them.

Faeroe - Shetland Channel

Based on a single line of processed, 3min (1.5min subseabed), deep seismic exploration data kindly supplied by British Petroleum illustrating suspected gas chimneys and enhanced reflectors, a deep towed side scan sonar traverse (Lines 470-1) down the west Shetland slope, across the floor of the Faeroe - Shetland Channel and up the Faeroese side to approx 800m water depth was conducted. Parasound and hydrosweep were also run along this traverse. No obvious, gas related features were noted at the sites suggested by British Petroleum.

On the floor of the channel, close to the foot of the Faeroese slope, a large depression with steep walls was noted (approx 1km x 2km x 40m) on the hydrosweep (Fig. 10) and side scan sonar records. The parasound revealed little acoustic penetration of the floor of the depression suggesting the absence of a soft sediment infill. A CTD was collected from this site (Sta. 470-2) but no physical sampling. Several deep depressions attributed to current scouring have been noted previously from the centre of the channel, just east of this site (Stoker, 1989) and the depression located by this survey may have a similar origin.

The boomer was run along a profile (Line 471-2, Fig. 6) through all the sites suggested by BP and along a short cross profile (471-1) parallel to the channel thalweg through the site considered to have the greatest potential for shallow gas. No obvious evidence of shallow gas was seen on either profile. The boomer profiles suggest that the floor of the Faeroe - Shetland Channel comprises lensoid bodies locally separated by fine layered reflectors. Box cores were taken at several localities to reveal an extremely coarse bottom sediment, e.g. site 474 contained subrounded to angular multilithic clasts up to 20cm diameter within a light olive brown matrix of muddy sand to sandy mud, evidence of winnowing occured at the seabed. The lensoid bodies are probably cross-sections of sediment drifts. The side scan sonar indicated an along channel orientation to features close to the foot of the slope.

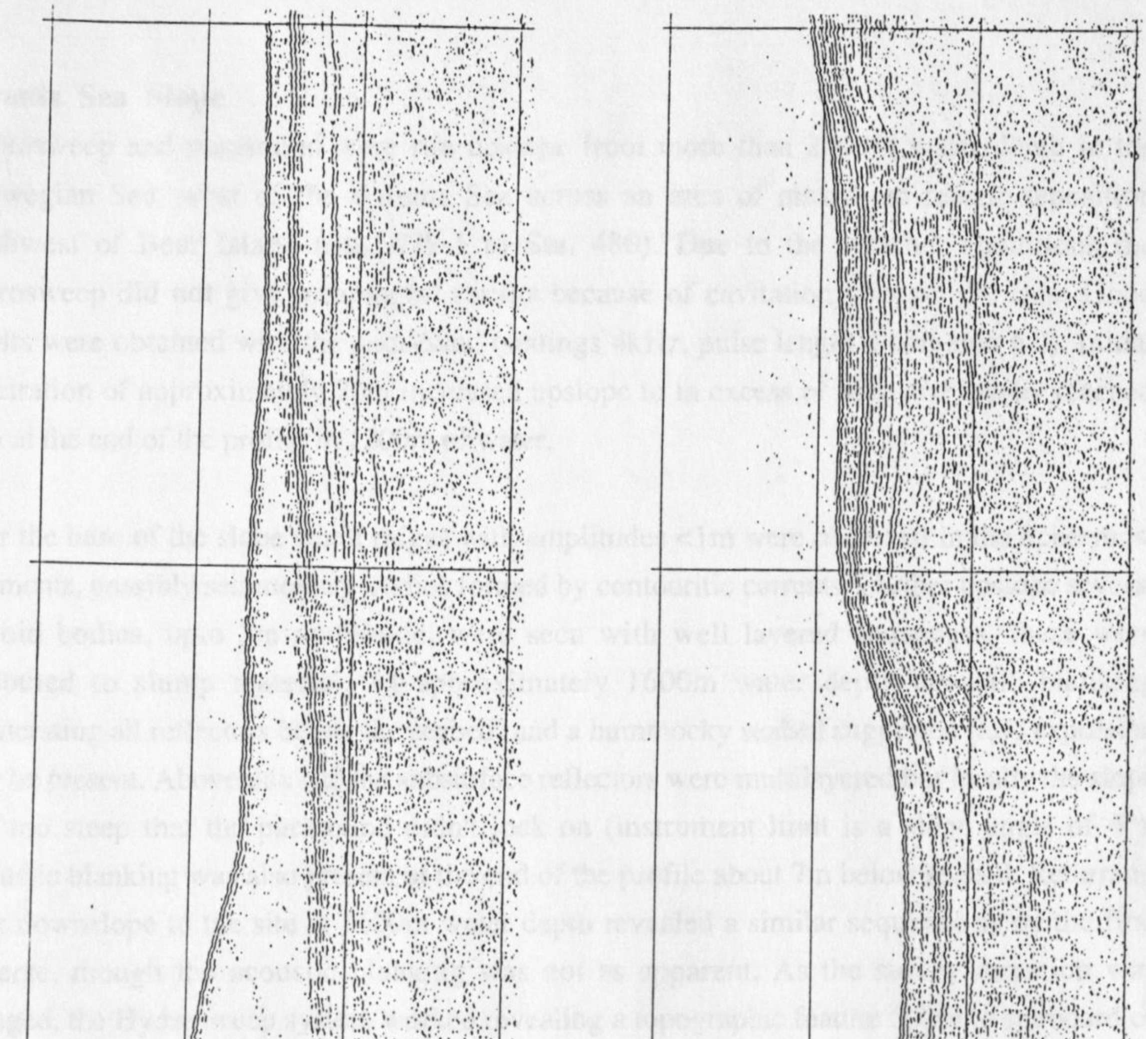


Fig. 6: Deep-tow boomer record on the SE-flank and bottom of the Faeroe-Shetland channel showing a sediment drift body thinning down slope and reduced sediment accumulation at the channel floor; the two sections shown are continuous and cover about the distance from Sta. 475 to the NW-end of the DTBS-line shown in Fig. 3; vertical scale 30ms, horizontal scale approx. 650m.

Barents Sea Slope

Hydrosweep and parasound were run upslope from more than 2000m water depth in the Norwegian Sea, west of the Barents Sea across an area of maximum recent deposition northwest of Bear Island (Sta. 479-1 to Sta. 480). Due to the weather conditions the hydrosweep did not give meaningful results because of cavitation beneath the ship. Good results were obtained with the parasound (settings 4kHz, pulse length 4 and gain 6.0). Initial penetration of approximately 20m increased upslope to in excess of 40m and locally reached 50m at the end of the profile in 1200m of water.

Near the base of the slope small ridges with amplitudes <1m were observed in the uppermost sediments, possibly sedimentary bodies formed by contouritic currents. Further upslope several lensoid bodies, upto 3m amplitude, were seen with well layered sequences, these were attributed to slump material. At approximately 1600m water depth acoustic blanking (obliterating all reflectors below the seabed) and a hummocky seabed suggested fluid expulsion may be present. Above this site the subsurface reflectors were multilayered but locally the slope was too steep that the parasound didn't lock on (instrument limit is a slope angle of 4°). Acoustic blanking was also present at the end of the profile about 7m below seabed. Returning back downslope to the site at 1600m water depth revealed a similar sequence as on the first traverse, though the acoustic blanking was not as apparent. As the survey direction was changed, the Hydrosweep system worked revealing a topographic feature 500m to starboard of the ship and this was believed to be the intended target. A third approach successfully traversed the feature which was sampled (Sta. 480-6) and contained some methane.

Barents Sea Crater Field

Three deep towed boomer profiles (Lines 488-1 to 488-3, Fig. 5) through several of the craters identified in the 1991 METEOR cruise (No. M17/2) confirmed the presence of pinnacles within some of the craters, particularly near the centre of the craterfield. They gave a hard acoustic response for the upper surface of the pinnacles with the crater floor recorded beneath, the side slopes of these features were too steep to be resolved on the boomer records. Parasound, echosounder and Hydrosweep were also run on these profiles, but with only limited success with the Hydrosweep. The gain on the echosounder was turned up high to detect interference (possible gas plumes) in the water column.

A grid of Hydrosweep lines (Lines 491-1 to 491-13) oriented at right angles to the swell mapped the bathymetry west of the existing data set with the aim of extending the area of known craters. Only a few more were identified. However, it confirmed that almost all the topographic highs recorded in 1991 outside the craters were erroneous, probably caused by "cross-talk". The distribution of craters exhibited a strong linear pattern representing two preferred orientations with bearings of 60° and 120°. These orientations were repeated to a lesser extent by the distribution of pinnacles within individual craters. It is therefore suggested that there may be some structural control on the distribution of the craters.

Strong hyperbola on the boomer records from the floors of several of the craters together with no acoustic penetration by the parasound suggested a hard irregular surface. This was subsequently proved by sampling as comprising broken fragments of rock. The seafloor surrounding the craters was basically a flat surface with a gentle dip to the S. This surface had a very strong acoustic response attributed to planar erosion such as by glaciers. Locally small mounds occur above this reflector suggesting post glacial deposition adjacent to the craters. The subsurface reflectors dip to the SE.

The friable nature and near monolithic composition of the rock recovered in the box cores suggests that the craters are postglacial in age. The clasts are frequently angular, sometimes with concoidal fractures and compose dark to light grey mudstones and siltstones often with abundant plant fragments. There were only a few subrounded, ice rafted pebbles, including a large clast with glacial straie.

Acoustic reflectors were noted to be downwarped beneath several of the craters indicative of significant acoustic velocity differences between the sediment of the crater walls and the water within the craters (Fig. 7). Basic calculations on the extent of downwarping revealed that the crater walls have acoustic velocities of 2200 - 2400 m/s which suggested that they comprise solid rock and not unconsolidated glacial products. Such values would be consistent with the lithology of recovered clasts in the box cores.

Enhanced reflectors ("bright spots") were observed below several craters, between 30 and 120msec (circa 35 - 150m) below the floor of the craters (Fig. 7). Such features have been attributed elsewhere to gas accumulations. No deep reflectors were noted beneath areas devoid of craters. Gas blanking was not observed anywhere suggesting that any concentrations would be low. This would fit with a solid subsurface where porosity is likely to be lower than in unconsolidated Quaternary sediments. With bottom water temperatures of (-0.2°C) and approximately 350m of hydrostatic pressure, any methane and water mixture present is likely to occur within the solid phase as methane hydrate. Though, with a geothermal gradient of about 3°C per 100m, free gas could exist at relatively shallow depths beneath the craters, possibly even at the levels of the enhanced reflectors noted on the boomer records.

References

Stoker, M.S. 1989. Judd, 60°N06°W, Seabed Sediments 1:250,000 map series, HMSO for the British Geological Survey.

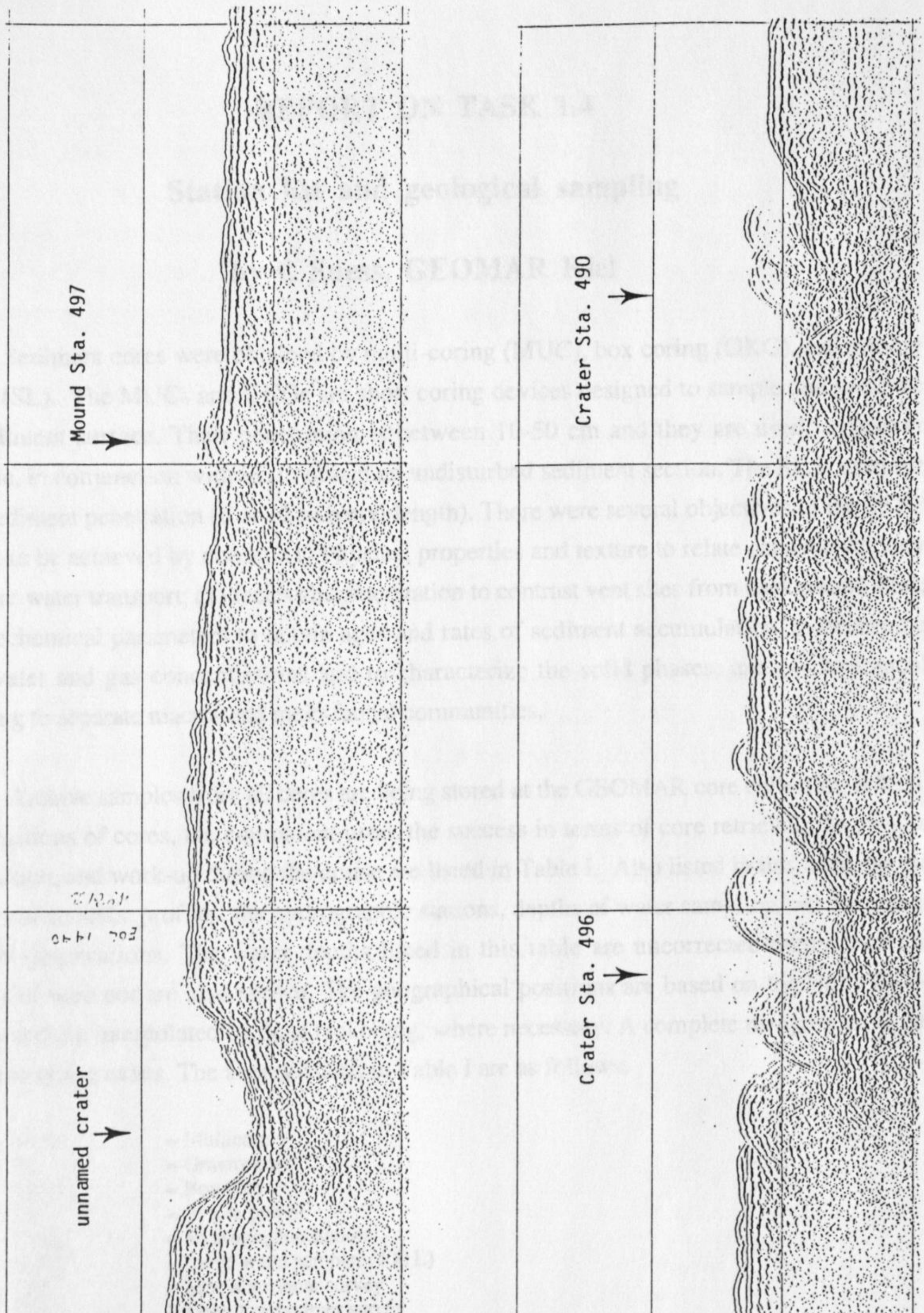


Fig. 7: Section of deep-tow boomer record in two parts (DTBS Line 2) across 3 craters (Sta. 490, 496 and 1 unsampled crater) and a sediment mound (Stat. 497) from the Barents Sea crater field; 2 of the craters have pinnacles and a complex morphology inside, the third shows a smooth morphology; enhanced reflectors beneath the unsampled crater; the surface surrounding the craters is a hard, flat surface with no acoustic penetration; vertical scale 30ms, horizontal scale approx. 650m.

REPORT ON TASK 1.4

Station list and geological sampling

by E Suess, GEOMAR Kiel

Sediment cores were obtained by multi-coring (MUC), box coring (GKG), and gravity coring (SL). The MUCs and GKGs are short coring devices designed to sample and preserve the sediment surface. Their penetration is between 10-50 cm and they are used, whenever possible, in conjunction with SL to obtain an undisturbed sediment section. The SL is used for deep sediment penetration (6 or 12 m barrel length). There were several objectives of the SEEP project to be achieved by coring: (1) Physical properties and texture to relate acoustic velocity and pore water transport; (2) facies characterization to contrast vent sites from background sites; (3) geochemical parameters to obtain ages and rates of sediment accumulation, to determine pore water and gas concentrations and to characterize the solid phases; and (4) biological sampling to separate macro- and meio-faunal communities.

Archive samples from all cores are being stored at the GEOMAR core collection at Kiel. The positions of cores, the equipment used, the success in terms of core retrieval, the sample distribution, and work-up during the cruise are listed in Table I. Also listed in this table are the surveys of acoustic profiles, the hydrographic stations, depths of water sampling, net sampling, and TV-observations. The water depths listed in this table are uncorrected depths and the lengths of wire out are also shown. The geographical positions are based on the ship's GPS-system and are interpolated by dead reckoning, where necessary. A complete navigation file for the entire cruise exists. The abbreviations in Table I are as follows:

MUC	= Multicore
SL	= Gravity core
GKG	= Box core
ISP	= in situ pump
CTD	= Hydrographic station
GWS	= Large water sampler (400 L)
SISS	= Side scan sonar survey
DTBS	= Deep-tow boomer survey
MEDUSA	= in situ methane detection system
HS	= Hydrosweep profiling
PS	= Parasound profiling
RN	= Single ring net sample
RSN	= Multiple ring net sample
MN	= Multi net sample
BG	= Grab sample
TV	= Underwater TV system

Skagerrak

The gravity corer was deployed twice in the Skagerrak area. It yielded two full 6-m barrels, 573 cm and 550 cm long. One of them was located at an active vent site the other at a background site. Several short companion cores were obtained at these sites as well; overall 10 cores were taken from the Skagerrak, their locations are shown in Fig. 2. The material of these cores is the basis for all sedimentological, geochemical, and biological work to come.

Faeroe-Shetland Channel

The objective in coring the floor and flanks of the Faeroe-Shetland Channel was to obtain material from the newly recognized sediment drift bodies, the channel fill and for separating the benthic fauna. Five GKGs and 1 MUC were obtained for these tasks from water depths between 983 and 1012 m (Table 1).

Barents Sea slope and Barents Sea shelf

Two GKGs were obtained from the slope station located above an acoustic anomaly indicative of gas venting. One of these cores was used for biological the other for pore water and geochemical sampling (Table 1). A total of 20 cores were taken from the crater field of the shelf (8 MUCs and 12 GKGs). The sampling strategy was to complement existing material from several craters for dating, from a mound the flat sea bottom between the craters. The distribution of the coring sites are shown in Figs. 4 and 5 and the relevant details are listed in Table 1.

Table 1: Station list of the R.V. METEOR Cruise 26-2

Stations - Nr. METEOR	Datum 1993	Gerät, Profil	von Deck	Zeit (UTC) auf Tiefe	an Deck	Geographische Breite (auf °N	Position Länge Tiefe) °E	Wasser-tiefe (m)	Seil-länge (m)	Eindringtiefe/ Gewinn (cm/cm)	Bemerkungen
460-1	30.9.	TV-MUC		09:39		58°02.935	09°38.670	336		55-58	
460-2		MUC		10:51		58°02.800	09°38.000	324		60	
460-3		MUC		11:28		58°02.711	09°38.385	312		47-55	
460-4		GKG		12:34		58°02.807	09°38.092	320		50	
460-5		GKG		13:24		58°02.769	09°38.039	320		0	
460-6		GKG		13:46		58°02.773	09°38.990	319		53	
460-7		CTD		14:39		58°02.605	09°39.791	304			T-S-Aufnahme arbeitet nicht
461-1		SISS	von	18:47		58°03.510	09°41.160				
			bis	19:22		58°02.300	09°38.300				
461-2		SISS	von	19:48		58°02.560	09°38.100				
			bis	20:45		58°03.750	09°40.900				
461-3		SISS	von	20:55		58°03.973	09°40.759				
			bis	21:32		58°02.700	09°37.800				
461-4		SISS	von	22:23		58°02.202	09°36.026				
			bis	23:30		58°04.500	09°41.500				
461-5	1.10.	SISS	von	01:42		58°04.567	09°35.699				
			bis	02:45		58°04302	09°39.113				
461-6		SISS	von	03:45		58°04.302	09°39.113				
			bis	04:17		58°03.040	09°41.266				
461-7		SISS	von	05:32		58°04.138	09°39.194				
			bis	05:52		58°03.373	09°40.492				
462-1		MEDUSA	von	12:30		58°02.100	09°46.000				
			bis	13:40		58°02.400	09°36.400				
463-1		CTD		14:01		58°02.973	09°39.116	336			Flaschen nicht geschlossen
463-2		CTD		15:41		58°02.813	09°39.195	321	300		
		Probentiefen:		25m, 50m, 75m, 100m, 200m, 250m, 275m, 300m, 315m							
463-3		SL		17:39		58°03.105	09°39.462	332		573	keine Oberfläche
464-1		SL		18:45		58°02.702	09°37.697	336		550	
465-1		CTD		20:13		58°03.326	09°40.822	327	300		
		Probentiefen:		25m, 50m, 75m, 100m, 150m, 200m, 250m, 275m, 300m, 307m							
466-1		CTD		21:29		58°03.699	09°40.167	352	342		
		Probentiefen:		25m, 50m, 75m, 100m, 150m 200m, 250m, 275m, 300m, 320m, 342m							
467-1		CTD		22:54		58°03.576	09°39.027	362	355		
		Probentiefen:		25m, 50m, 75m, 100m, 150m 200m, 250m, 300m, 325m, 355m							
467-2		ISP		23:35		58°03.661	09°39.104	368	100		
468-1	2.10.	MUC		04:30		58°03.154	09°39.505	335		60	
468-2		GKG		05:21		58°03.148	09°39.507	334		55	
468-3		GKG		05:59		58°03.146	09°39.431	334		48	
469-1		GKG		07:01		58°02.635	09°37.914	332		45	
469-2		GKG		07:38		58°02.582	09°37.688	328		55	
470-1	4.10.	SISS	von	02:30		60°19.866	04°27.413W	643			
			bis	10:27		60°32.221	05°11.541W	808			
470-2		CTD		13:10		60°29.488	05°08.541W	1021	1011		
		Probentiefen:		500m, 550m, 600m, 650m, 700m, 750m, 800m, 850m, 900m, 925m, 950m, 980m, 990m, 1000m, 1005m, 1011m							
471-1		DTBS	von	16:26		60°25.000	04°55.500W				HS, PS
			bis	17:12		60°27.500	04°52.900W				
471-2		DTBS	von	18:45		60°26.200	04°54.400W				HS, PS
			bis	21:09		60°22.100	04°36.800W				
472-1	5.10.	CTD		01:26		60°25.908	04°54.250W	993	960		
		Probentiefen:		15m, 25m, 50m, 75m, 100m, 125m, 250m, 500m, 600m, 700m, 750m, 800m, 900m, 950m, 960m							
473-1		ISP		02:24		60°25.901	04°54.301W	994	200		
474-1		MUC		06:29		60°26.013	04°54.481W	991		28	
474-2		GKG		07:34		60°26.024	04°54.478W	993		30	
474-3		GKG		08:28		60°26.119	04°54.589W	1012		35	
474-4		GKG		09:45		60°26.324	04°54.163W	1018		20	
475-1		GKG		11:06		60°23.859	04°45.424W	983		25	
475-2		GKG		12:01		60°23.695	04°44.259W	984		35	
476-1	8.10.	CTD		03:55		63°45.068	05°00.040W	2901	2850		
		Probentiefen:		8m, 43m, 68m, 93m, 150m, 300m, 600m, 1000m, 1500m, 2000m, 2500m, 2850m,							
477-1		CTD		19:53		65°49.404	03°16.415W	2291	2285		
		Probentiefen:		8m, 18m, 33m, 42m, 75m, 100m, 150m, 200m, 300m, 600m, 1000m, 1500m, 2000m, 2265m							
477-2		RSN		22:29		65°49.769	03°18.834W	2326	1000		
477-3		RSN		23:57		65°50.033	03°19.220W	2301	500		Fehlversuch
477-4	9.10.	RSN		00:30		65°50.183	03°19.425W	2378	500		
477-5		RSN		01:20		65°50.462	03°19.662W	2612	100		

Table 1: Station list of the R.V. METEOR Cruise 26-2 (continued)

Stations - Nr. METEOR	Datum 1993	Gerät, Profil	von Deck	Zeit (UTC) auf Tiefe	an Deck	Geographische Breite (auf °N	Position Länge Tiefe) °E	Wasser-tiefe (m)	Seil-länge (m)	Eindringtiefe/ Gewinn (cm/cm)	Bemerkungen
477-6		GKG		02:54		65°49.393	03°16.125W	2275		35	
478-1	10.10.	CTD		03:31		70°00.000	00°00.006W	3297			
		Probentiefen:		15m, 25m, 50m, 100m, 150m, 200m, 500m, 1000m, 1500m, 1700m, 2000m, 2300m, 2500m, 2800m, 3000m, 3238m							
478-2		RSN		06:00		70°00.005	00°00.116W	3297	1000		
478-3		RSN		06:59		70°00.084	00°00.069W	3298	500		
478-4		RSN		07:34		70°00.054	00°00.151W	3301	100		
478-5		ISP		08:16		70°00.037	00°01.281W	3300	100		
478-6		GKG		11:43		70°00.335	00°03.793W	3296		50	
479-1	12.10.	PS	von	07:09		74°58.967	13°20.332				
			bis	10:25		74°59.000	14°55.000				
480-1		CTD		12:40		74°59.114	14°22.532	1589	1564		
		Probentiefen:		15m, 50m, 100m, 250m, 750m, 1000m, 1480m, 1530m, 1564m							
480-2		ISP		14:32		74°59.218	14°22.192	1582	1500		
480-3		RN		16:58		74°59.345	14°22.358				Fehler beim Aussetzen
480-4		MN		17:48		74°59.974	14°22.449	1542	1000		
480-5		GKG		20:10		74°59.055	14°22.032	1600		43	
480-6		GKG		22:00		74°59.025	14°22.600	1607		43	
481-1	13.10.	CTD		05:49		74°50.940	16°56.943	308	300		
		Probentiefen:		20m, 25m, 50m, 80m, 100m, 120m, 150m, 170m, 200m, 230m, 250m, 280m, 291m							
481-2		GWS		06:50		74°51.014	16°57.245	308	120		
482-1		TV		12:51		75°13.816	18°38.085	25			
482-2		BG		13:08		75°13.828	18°38.103	25			10 Stück
483-1		TV		13:59		75°13.926	18°43.840	25			
483-2		BG		14:18		75°13.897	18°43.660	25			10 Stück
484-1		TV		15:06		75°13.916	18°49.624	25			Stecker undicht
484-2		BG		15:18		75°13.916	18°49.621	25			10 Stück
485-1		TV		16:17		75°10.980	19°00.173	25			
485-2		BG		16:25		75°10.952	18°59.617	28			10 Stück
486-1		TV		20:44		75°07.651	19°49.356	42			
486-2		BG		21:13		75°08.289	19°49.450	42			10 Stück
487-1	14.10.	BG		11:29		75°02.031	22°57.806	104			9 Stück
488-1	17.10.	DTBS	von	11:57		74°53.100	27°24.600				
			bis	13:10		74°55.300	27°40.000				
488-2		DTBS	von	13:46		74°54.100	27°40.00				
			bis	14:41		74°56.200	27°30.000				
488-3		DTBS	von	15:15		74°54.700	27°32.000				
			bis	15:48		74°55.500	27°40.000				
489-1		GKG		17:58		74°55.351	27°33.770	358		15-23	
489-2		GKG		18:58		74°55.347	27°33.783	351		leer	
490-1		CTD		19:15		74°55.597	27°33.728	340	321		
		Probentiefen:		15m, 50m, 100m, 200m, 225m, 250m, 275m, 300m, 321m							
491-1		HS-PS	von	20:45		74°56.000	27°34.000				
			bis	21:20		75°00.000	27°33.600				
491-2		HS-PS	von	21:35		75°00.000	27°33.300				
			bis	22:12		74°55.500	27°34.000				
491-3		HS-PS	von	22:26		74°55.000	27°34.00				
			bis	23:07		75°00.000	27°20.900				
491-4		HS-PS	von	23:13		74°59.900	27°20.000				
			bis	23:54		74°54.500	27°34.000				
491-5	18.10.	HS-PS	von	00:04		74°54.000	27°34.000				
			bis	00:39		74°58.000	27°23.700				
491-6		HS-PS	von	00:47		74°58.000	27°22.400				
			bis	01:23		74°53.600	27°34.000				
491-7		HS-PS	von	01:31		74°53.100	27°34.000				
			bis	02:24		74°58.000	27°21.100				
491-8		HS-PS	von	02:26		74°58.000	27°20.000				
			bis	03:06		74°52.600	27°34.000				
491-9		HS-PS	von	03:17		74°51.100	27°34.000				
			bis	04:13		74°57.500	27°20.000				
491-10		HS-PS	von	04:21		74°57.000	27°20.000				
			bis	05:01		74°52.000	27°22.900				
491-11		HS-PS	von	05:11		74°52.000	27°31.700				
			bis	05:54		74°56.500	27°20.000				
491-12		HS-PS	von	06:02		74°56.100	27°20.000				
			bis	06:33		74°52.000	27°30.400				
491-13		HS-PS	von	07:14		74°52.000	27°29.100				
			bis	07:45		74°55.600	27°19.600				
492-1		CTD		08:23		74°54.365	27°39.133	347	350		5 Flaschen nicht geschlossen
492-2		CTD		09:03		74°54.227	27°39.130	353	344		
		Probentiefen:		15m, 50m, 100m, 200m, 250m, 270m, 290m, 310m, 325m, 344m							
492-3		MUC		10:06		74°54.203	27°39.000	351		18	1 Rohr gefüllt
492-4		MUC		10:27		74°54.212	27°39.178	351		18-23	

Table 1: Station list of the R.V. METEOR Cruise 26-2 (continued)

Stations - Nr. METEOR	Datum 1993	Gerät, Profil	Zeit (UTC) von Deck	auf Tiefe	an Deck	Geographische Breite (auf °N	Position Länge Tiefe) °E	Wasser-tiefe (m)	Seil-länge (m)	Eindringtiefe/ Gewinn (cm/cm)	Bemerkungen
492-5		GKG		11:20		74°54.228	27°39.214	356		49	
492-6		GKG		12:01		74°54.279	27°39.179	352		leer	
492-7		GKG		12:42		74°54.269	27°39.131	356		25	
492-8		GKG		13:17		74°54.215	27°39.200	358		38-45	
493-1		CTD		14:19		74°55.057	27°34.948	347	353		
		Probentiefen:		15m, 50m, 100m, 200m, 250m, 275m, 300m, 320m, 340m, 354m							
493-2		VESP				74°54.996	27°34.749	325			
494-1	19.10.	VESP				74°57.000	27°36.000				
495-1		VESP				74°55.600	27°32.500				
496-1		CTD		06:43		74°55.300	27°31.496	345	339		
		Probentiefen:		15m, 50m, 100m, 200m, 250m, 275m, 300m, 325m, 339m							
496-2		GKG		07:38		74°55.259	27°31.601	370		15	
496-3		GKG		08:32		74°55.434	27°32.421	356		30	
496-4		GKG		09:10		74°55.506	27°32.316	351			
496-5		GKG		09:52		74°55.505	27°32.201	349		25	
496-6		GKG		10:35		74°55.486	27°32.211	340			ausgewaschen
496-7		MUC		11:31		74°55.508	27°32.372	359			eingefroren
496-8		MUC		12:31		74°55.531	27°32.527	356		25	
497-1		MUC		13:15		74°55.720	27°31.654	341		20	
497-2		MUC		13:48		74°55.787	27°31.489	342		30	
497-3		GKG		14:35		74°55.785	27°31.575	341		35	
497-4		GKG		15:08		74°55.793	27°31.636	340		leer	
497-5		GKG		15:50		74°55.852	27°31.764	340		38	
498-1		CTD		16:50		74°57.000	27°35.900	340	339		
		Probentiefen:		15m, 50m, 100m, 200m, 250m, 275m, 300m, 315m, 335m							
499-1		CTD		23:32		75°45.000	27°47.700	261			0 - 60m keine CTD-Daten
		Probentiefen:		15m, 25m, 50m, 75m, 100m, 150m, 200m, 220m, 230m, 241m							

REPORT ON TASK 1.5

Video images & survey

by P Linke, P Dando

VEnt SPider (VESP), a remotely operated deployment system with deep-sea TV/photo capabilities, was used on three casts in the Barents Sea to perform a video and photo survey of the crater field.

493-2

VESP was deployed in a 30 m deep pockmark with a vertical pillar of equivalent height to the crater depth (Fig. 8a). The base of this pockmark was of mud with occasional angular slabs of mudstone lying on the bottom or slightly protruding through the sediment cover. Sponges, corals and anemones were common on top of the rocks. Fish, mainly cod, were present in large numbers in the deepest part of the depression (Fig. 8b). Rock slabs were increasingly common towards the pockmark base and at the base of the pillar. The pillar itself had almost vertical slides with small, knobbly but rather angular protuberances (Fig. 8c). It did not have the smoothed surface appearance of the carbonate pillars in the Kattegat and had a sediment covering. Small rocks fell off when the feet of the VESP knocked it. The top was flat and lightly sediment covered with anemones growing on it.

The sides of the pockmark were steep with mudstone slabs. Conspicuous mudstone was also observed around the rim of the crater, suggesting explosive release from the crater base.

494-1

The deployment was in the northern pockmark in the previously surveyed area. It had steep sides and no internal protuberances. Sides and base were sediment covered with few physical features except for very occasional small rocks protruding through this cover (Fig. 8e). Small anemones were common and numerous polychaete tubes were visible (Fig. 8d, f). Shrimps and starfish were seen and fish, especially cod, were very numerous in the base. Sediment falling from the feet of the VESP was consolidated and frequently fell as lumps. Crustacean burrows were more common than in the other deployments, suggesting thicker sediment cover.

495-1

The VESP camera was used to survey the base of the pockmark centred at 74°55.5'N and 27°32.5'E. On reaching the bottom, 360 m water depth on the echo sounder, a series of mudstone slabs was observed. These were frequently observed to have straight edges and sides, some having an almost 'tombstone' appearance (Fig. 8g). The largest blocks rose 1 - 1.5 m above the pockmark base, were several metres across and frequently had fractured pieces of mudstone lying on their otherwise smooth tops. The tops of the slabs often appeared to be more sediment covered than the rock litter at their bases. Large sponges and corals grew on the edges of the rock and on rock slabs angling out of an apparently thin sediment cover between the large blocks. Crustacean burrows were not common, suggesting shallow sediment. Shrimps were occasionally visible as were dense swarms of Euphorsids. Anemones were particularly common where there was thin sediment cover. Where the rocks were less frequent, perhaps 1 m deeper in the pockmark base, numerous fish, particularly cod, were observed. Occasional *Hippoglossoides* were also seen. No evidence of seepage was observed, e.g. dark sediment, water movement, bacterial mats, seep associated fauna.

The overall impression of the pockmark base was of an old slate quarry (Fig. 8i). Some slabs were seen, lying against others, with their long axis almost vertical (Fig. 8h). What appeared originally to have been a mudstone layer over 1 m thick at the base of the depression had been fractured with lighter pieces of rock flung on top of the larger blocks.

Towards the end of the deployment the ship moved east to allow a view of the 10 m high mound in the northern part of the pockmark. This proved to be a mound of broken mudstone with light sediment covering and the usual epifauna. Beyond this in the western depression was an apparently more heavily sediment covered area, although only a few metres of this were covered before retrieval.

Fig. 8a:

Within the pockmark a vertical pillar of equivalent height to the carter depth became visible.

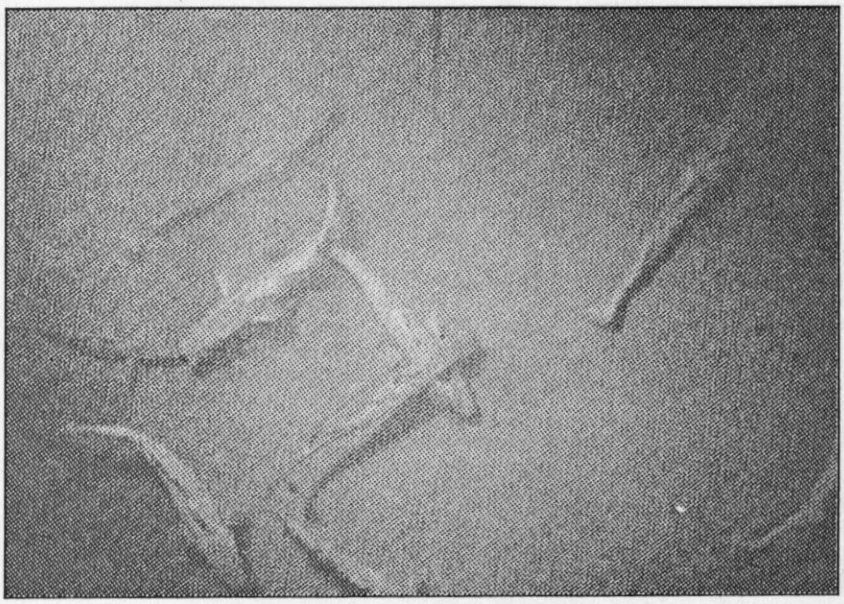


Fig. 8b:

In the deepest parts of the depressions fish, mainly cod, were present in large numbers.

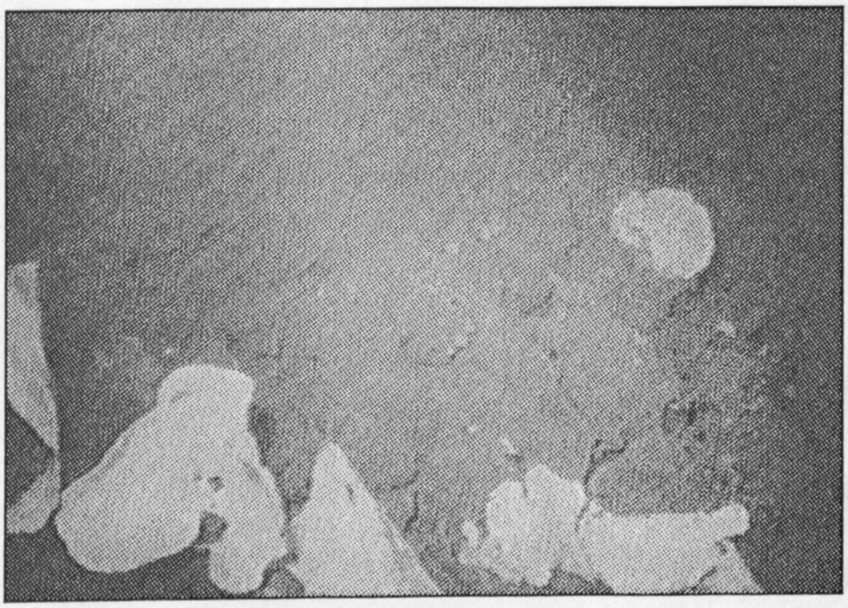


Fig. 8c:

The pillar had almost vertical sides with small, knobbly but rather angular protuberances which were colonized by large sponges.

Fig. 8d:

Side and base of the pockmark were sediment covered and polychaete tubes were visible.

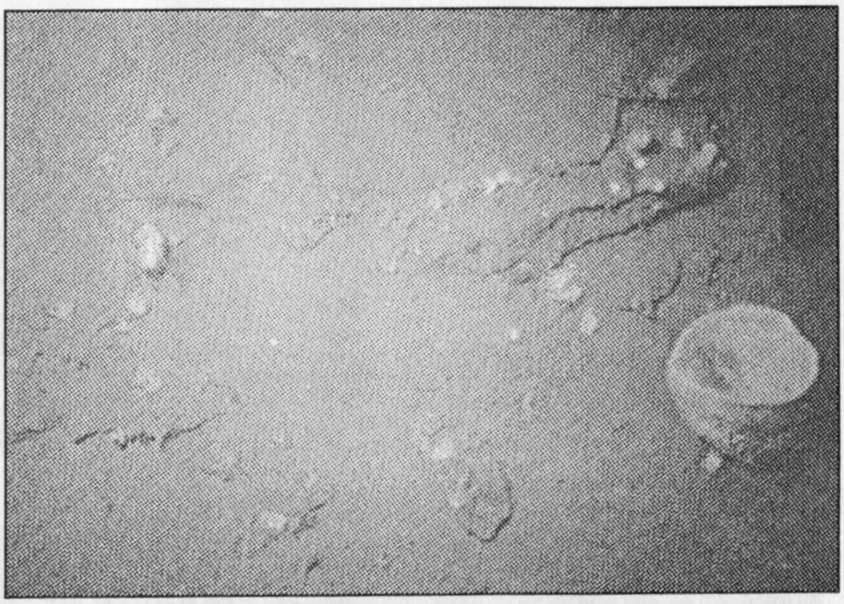


Fig. 8e:

Occasional rocks protuding the sediment were colonized by sponges and anemones.

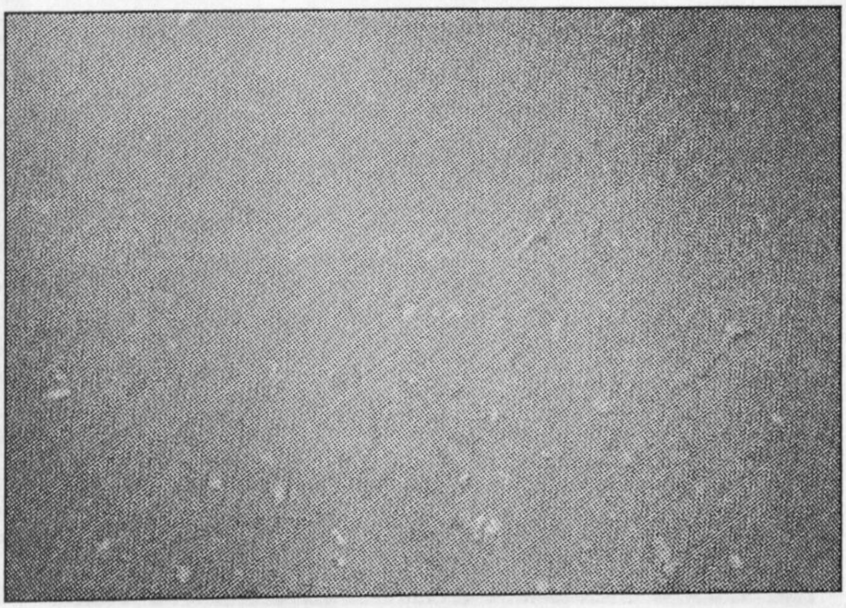


Fig. 8f:

Numerous anemones colonizing small rocks.

495-1 VESP

Fig. 8g:

Within the pockmark s series of mudstones was observed with straight edges and sides.

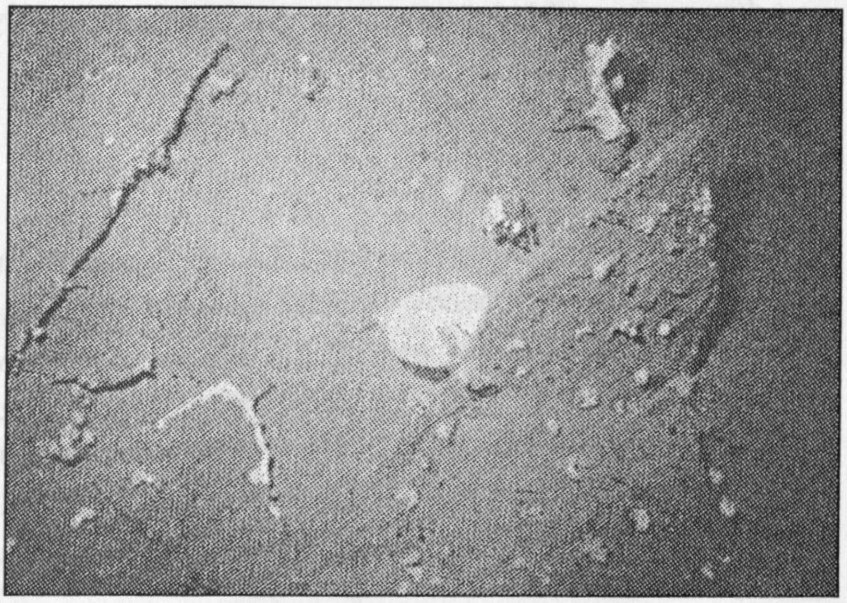


Fig. 8h:

Upright slabs with edges densely colonized.

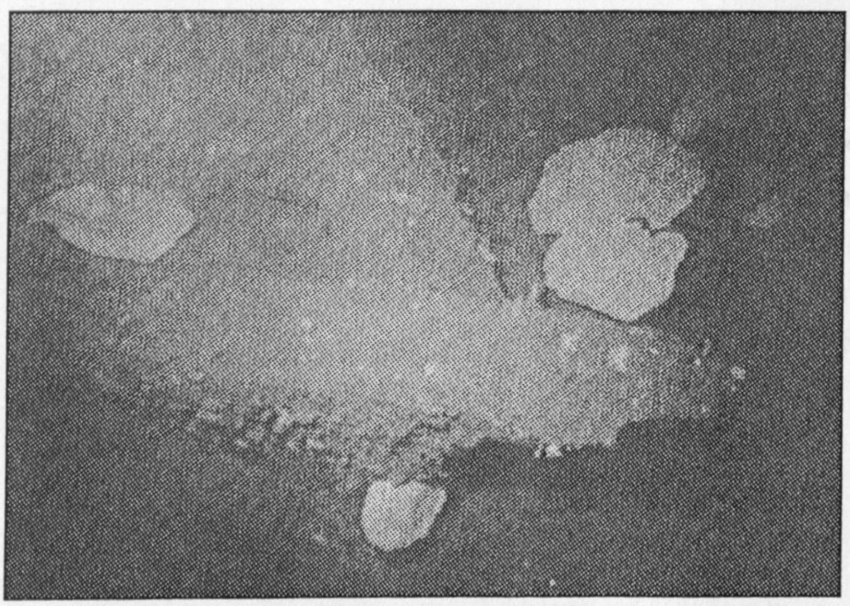


Fig. 8i:

Large sponges and anemones; the appearance of the pockmark base was of a slate quarry.

REPORT ON TASK 2

by S Lammers, GEOMAR Kiel

Methane in the water column

Methane analyses of hydrocast samples were originally intended as a vertical high resolution detection in addition to the long-distance surveys of MEDUSA. After the severe storm damage of October 15th, analyses on hydrocasts remained the only opportunity to geochemically explore active seepage. Of 14 hydrocasts a total of 100 samples were degassed immediately after recovery by application of vacuum and ultrasonic energy (Schmitt et al., 1991; Lammers & Suess, submitted). Aliquots of the extracted gas were analysed on board for methane with a Shimadzu GC 14A FID system.

Skagerrak

In order to track active seeps in the Skagerrak area, CH_4 analyses were run mostly on bottom-near water samples from 5 hydrocasts (see Fig. 2 for Stations). Bottom water CH_4 anomalies were between 1480 nl/l (Station 463-2) and 370 nl/l (Station 465-1) in all profiles and document the abundance of active seeps over the whole area (Fig. 9). According to the observed gradients, the best result.was achieved at Site 463-2, where the CH_4-concentration increased to more than 1300 nl/l within 20 m above the bottom. This indicates a point source nearby, probably an active seep along the line established between the CHALLENGER 82 Site and the METEOR 464 Site.

A gravity core recovered later at this location supports the evidence for seep activity. Subsamples of the core were preserved in liquid nitrogen for later analyses of total methane. At the Stations 460-7 and 463-2 a second CH_4 maximum above 250 m of water depth indicates additional lateral influences from more remote seeps of gas-rich fluids in the vicinity. At both locations surface-near values were about 200 nl/l, which is about 300 % supersaturated with respect to atmospheric concentrations (Wiesenburg & Guinasso, 1979). Similar patterns may also be expected at Stations 465-1, 466-1, and 467-1 (Fig.9b). Here only the near-bottom water column was sampled.

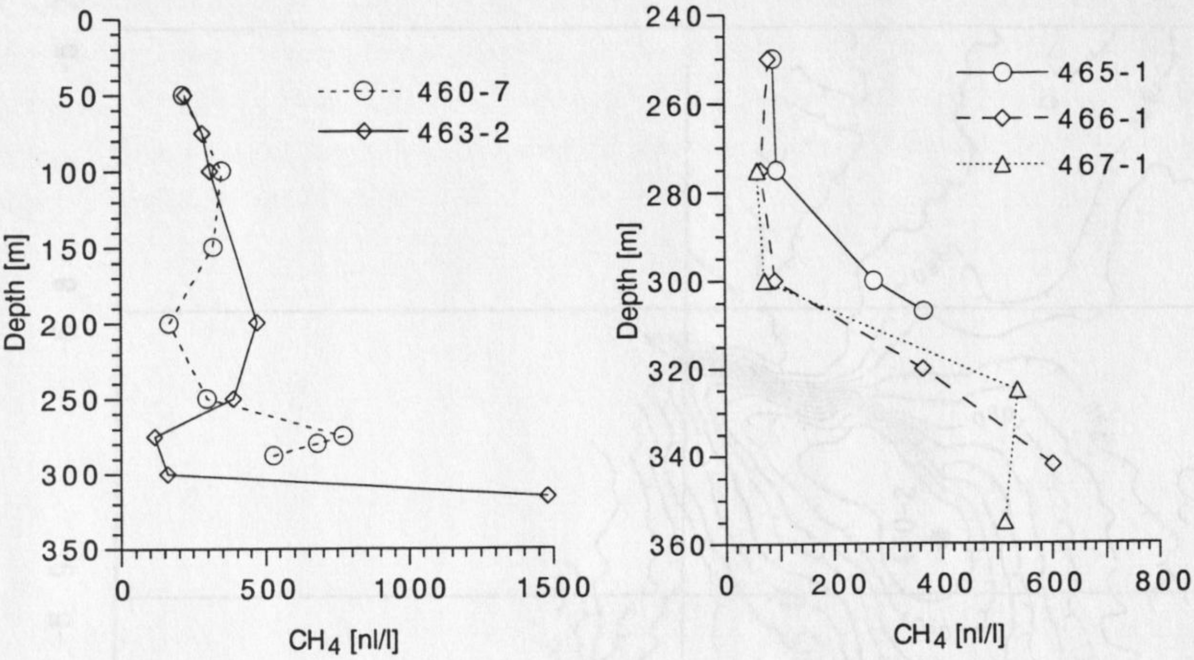


Fig. 9a

Fig. 9b

Fig.9a,b: Methane distribution in the water column at the Skagerrak Sites; station locations 460-7 to 467-1 are shown in Fig. 2. Station 463-2 located closest to the "seep-line", connecting the CHALLENGER 82 Site and the METEOR Station 464-1, has the highest CH_4-content in the bottom water, the other Stations also show strong enrichments of CH_4 in bottom waters, although not as pronounced as Sta. 463-2, indicating methane injection.

In general, the methane measurements confirmed that active seeps greatly affect all near-bottom waters and, to some extent, even the higher water column at the Skagerrak Sites.

North Atlantic and Barents Sea slope

Methane analyses were run on two CTD-casts at the Faroe-Shetland Channel (Stations 470-2, 472-1) to clarify the existence of gas seepages which had been indicated by previous seismic recordings and which was suspected from the crater-like depression in the channel floor (Fig. 10) Both profiles reveal a typical background distribution, slightly influenced by methane bearing water masses between 400 and 600 m but with no evidence for any methane release from adjacent sedimentary sources (Fig. 11a).

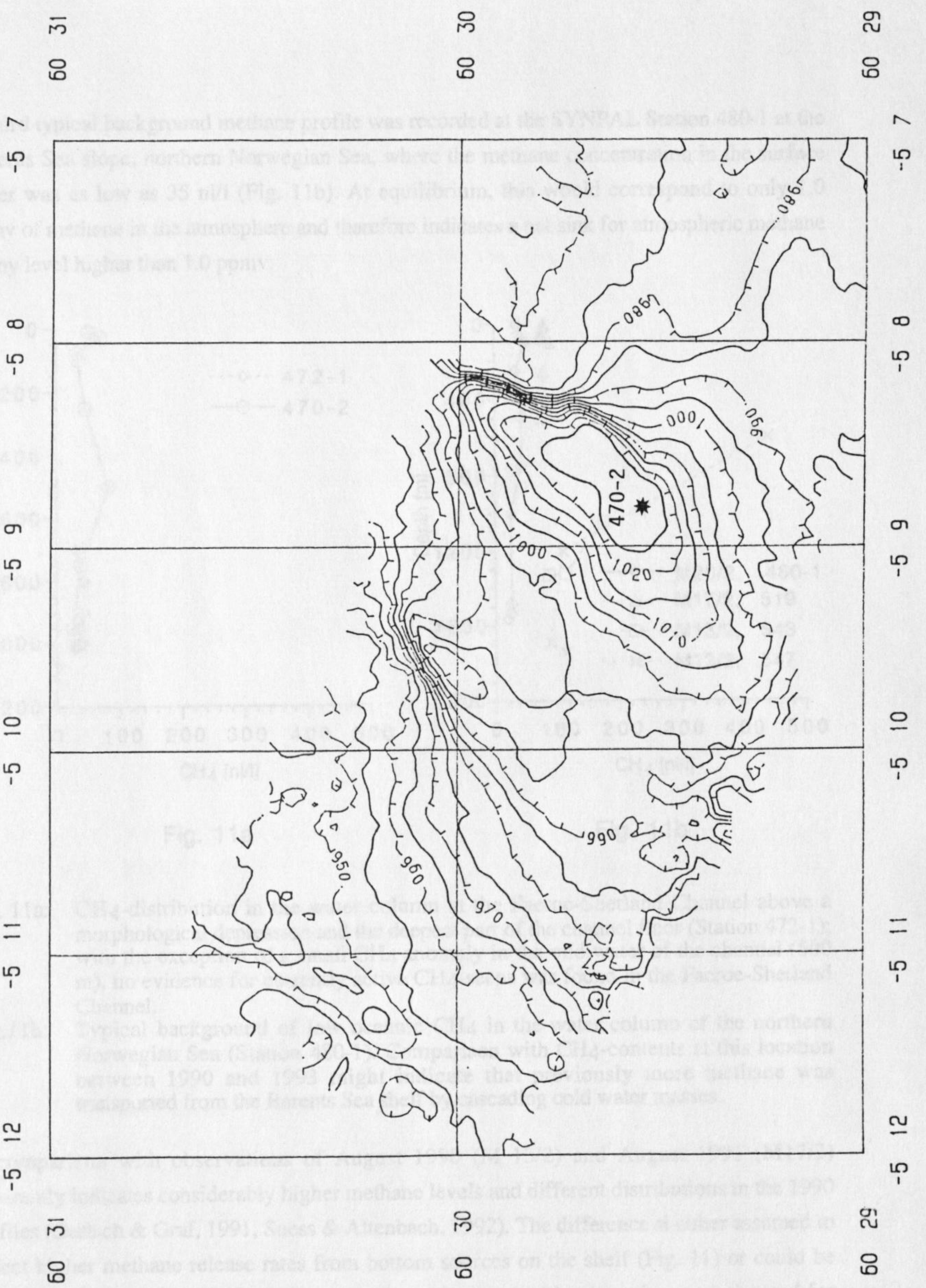


Fig.10: Depression in the Faeroe-Shetland Channel floor as seen in the Hydrosweep survey. Initially this structure was thought to be a gas hydrate blow-out crater. This hypothesis was however dicounted when no CH_4 anomaly was found in the bottom water (Station 470-2).

A third typical background methane profile was recorded at the SYNPAL Station 480-1 at the Barents Sea slope, northern Norwegian Sea, where the methane concentration in the surface water was as low as 35 nl/l (Fig. 11b). At equilibrium, this would correspond to only 1.0 ppmv of methane in the atmosphere and therefore indicates a net sink for atmospheric methane at any level higher than 1.0 ppmv.

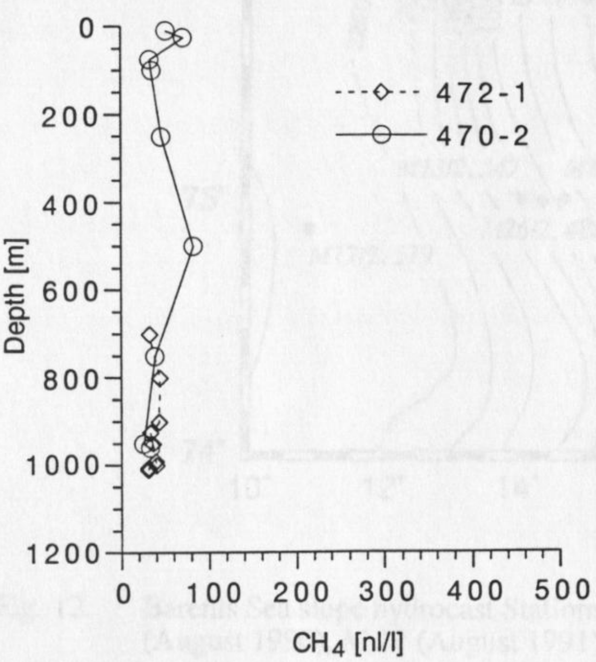


Fig. 11a

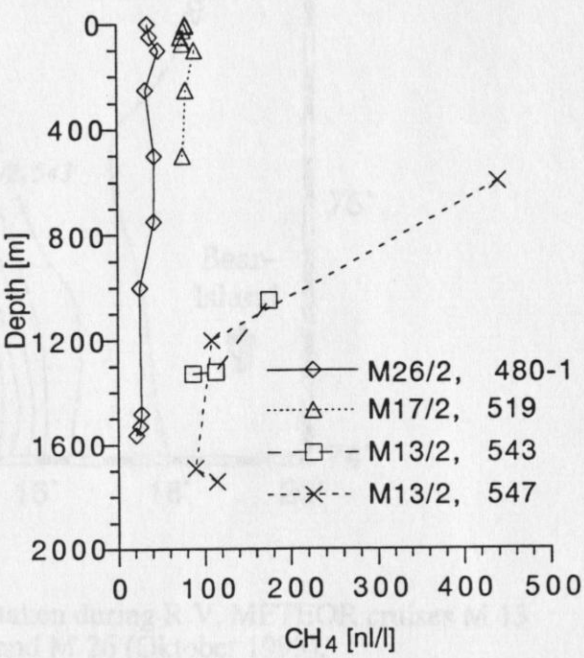


Fig. 11b

Fig. 11a: CH_4-distribution in the water column at the Faeroe-Shetland Channel above a morphological depression and the deepest part of the channel floor (Station 472-1); with the exception of a small CH_4 anomaly in the mid-water of the channel (500 m), no evidence for currently active CH_4-seeps was found in the Faeroe-Shetland Channel.

Fig.11b: Typical background of low oceanic CH_4 in the water column of the northern Norwegian Sea (Station 480-1). Comparison with CH_4-contents at this location between 1990 and 1993 might indicate that previously more methane was transported from the Barents Sea shelf by cascading cold water masses.

A comparison with observations of August 1990 (M 13/2) and August 1991 (M17/2) apparently indicates considerably higher methane levels and different distributions in the 1990 profiles (Gerlach & Graf, 1991, Suess & Altenbach, 1992). The difference si either assumed to reflect higher methane release rates from bottom sources on the shelf (Fig. 11) or could be related to analytical problems, although the degassing method has been in use unchanged for over 3 years. Inspection of the raw data should clarify whether or not analytical problems might be responsible.

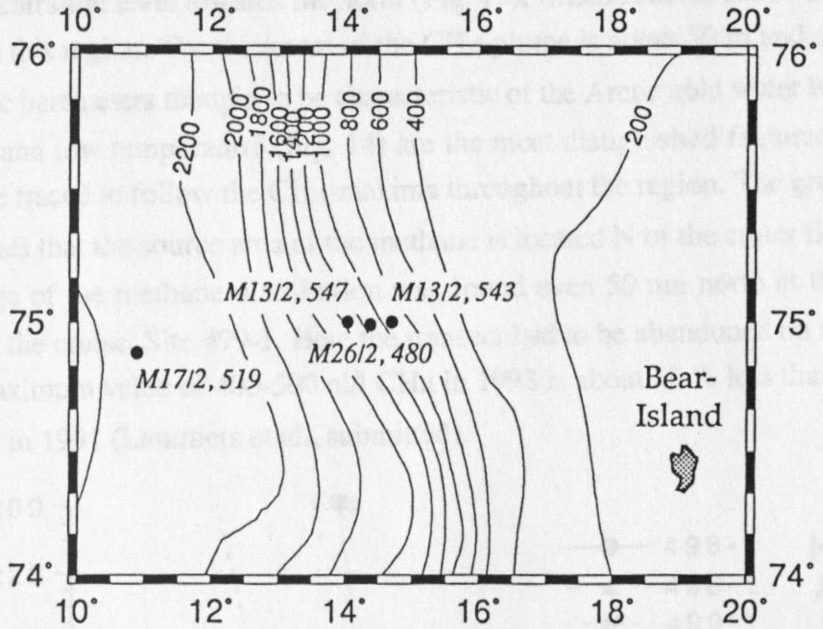


Fig. 12: Barents Sea slope hydrocast Stations taken during R.V. METEOR cruises M 13 (August 1990), M 17 (August 1991) and M 26 (Oktober 1993).

The decrease of methane concentrations by 50 % in the upper water column between 1991 and 1993 is less significant since the 1991 profile was recorded at greater distance to the slope (Fig. 12). Although these observations were made at about the same time of year and thus do not allow to conlude on the whole range and frequency of these variations, they are assumed to outline the magnitude of annual or longer-term variability of methane discharge on the Barents Sea shelf.

Barents Sea crater field

For investigations of known gas seepages and further mapping of a large methane plume that was observed on METEOR cruise 17/2 in August 1991 (Lammers et al., submitted; Suess & Altenbach, 1992), methane analyses were run on 35 of near-bottom samples from 5 hydrocasts within a crater area 260 km ENE of Bear Island and at one location about 50 nm north. According to previous investigations (Solheim & Elverhøi, 1985) and the PARASOUND sediment profiling on M26/2 and M17/2, the craters are thought to have been formed by explosive gas eruptions, although none of them was found to contribute to the presently observed methane anomaly on either survey. A slight decrease of salinity, oxygen, nitrate, and phosphate in the bottom water of a crater at Site 493-1 is not accompanied by any methane gradient and thus is a doubtful indication for seepage. Methane distributions were similar to those observed in 1991, all showing strong maxima below 280 m water depth. A destinctly increasing concentration level towards the north (Fig. 13), which follows the N-S flow of arctic bottom water in this region. The thickness of the CH_4-plume is about 50 m and corresponds to the hydrographic parameters thought to be characteristic of the Arctic cold water bottom current. Elevated silica and low temperature (Fig. 14) are the most distiguished features of this water mass and can be traced to follow the CH_4-maxima throughout the region. The gradient towards the north suggests that the source area of the methane is located N of the crater field. However, no major change of the methane distribution was found even 50 nm north at the last Station sampled during the cruise, Site 499-1. Here the transect had to be abandoned on account of ice. The average maximum value of 400-500 nl/l CH_4 in 1993 is about 50 % less than that found in the 17/2 survey in 1991 (Lammers et al., submitted).

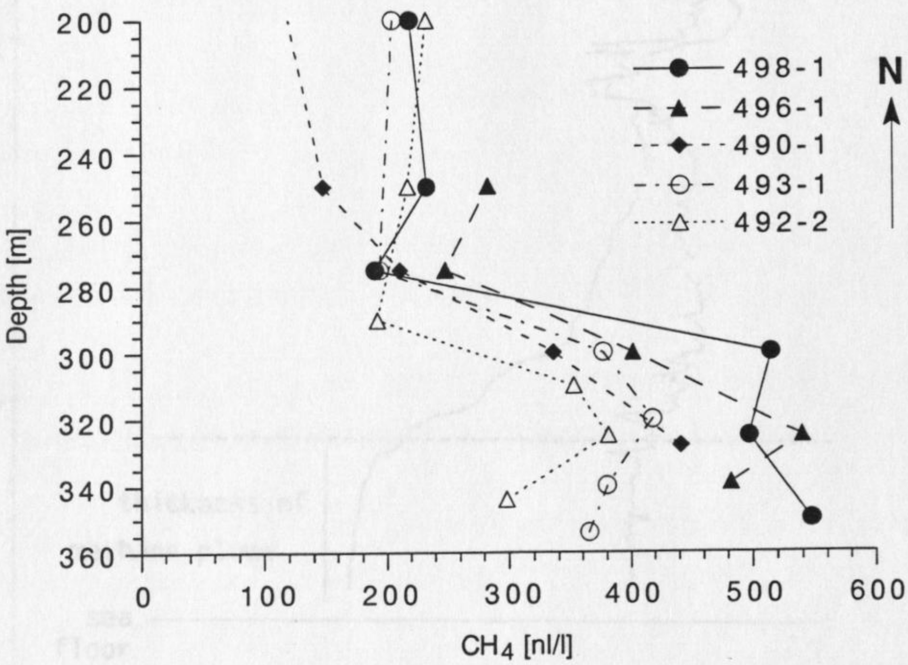


Fig. 13

Fig. 13: CH_4 in the bottom water of the Barents Sea shelf in the vicinity of the crater field; not systematic increase of CH_4 towards the north; for Station locations see Fig. 5.

This discrepancy was also observed in the CH_4-concentration changes at the Barents Sea slope and probably reflects the variability of the supply of marine methane. An increased degassing of methane into the atmosphere caused by weather induced mixing or a variation of the seep activities on the Barents Sea shelf are considered responsible for the lower concentrations in dissolved methane.

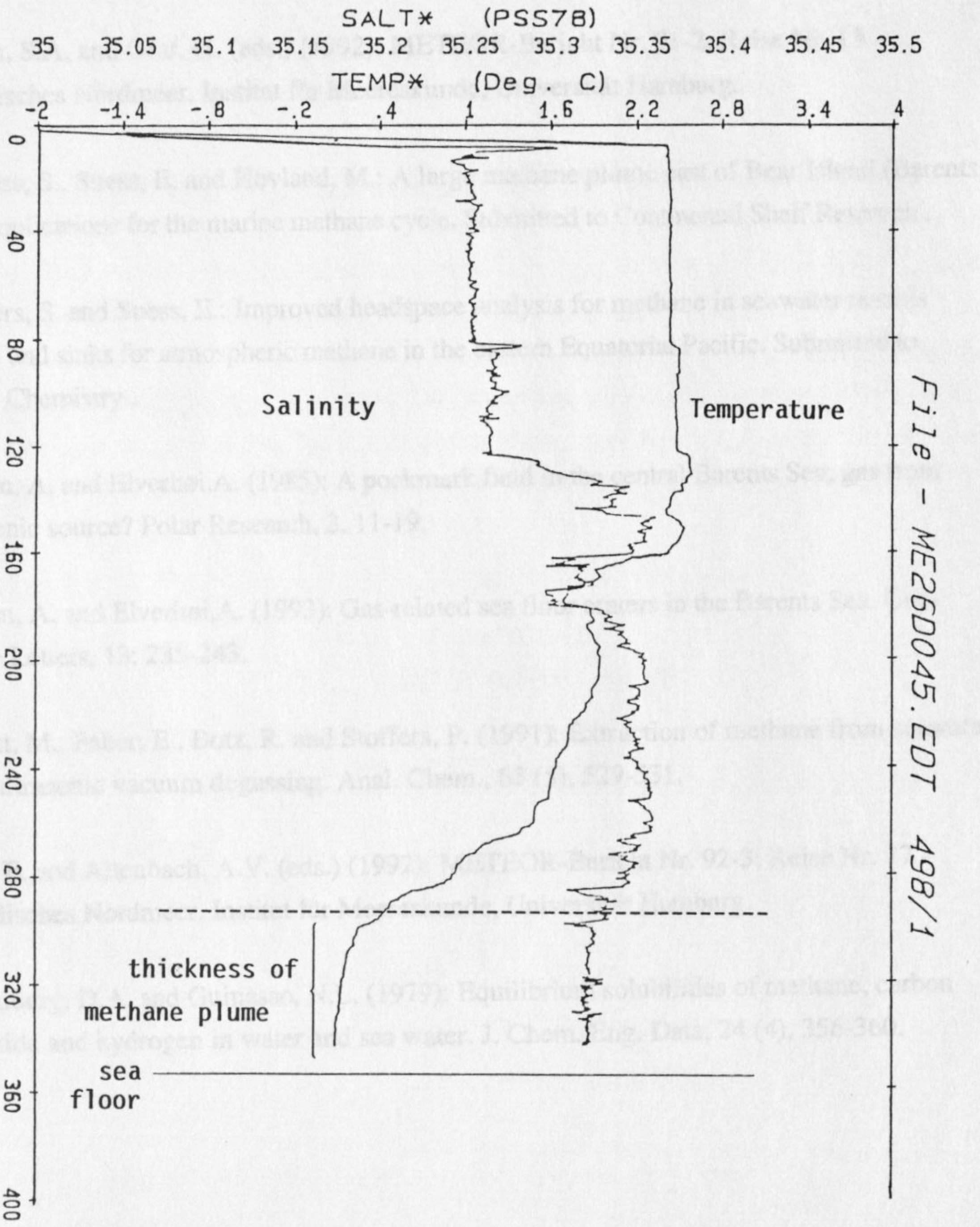


Fig. 14: Salinity and temperature of Barents Sea shelf waters; Station 498-1 shows low temperature bottom water below ~290 m depth; the low temperature water mass corresponds to the thickness of the CH_4 plume found in this area.

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Schmitt, M., Faber, E., Botz, R. and Stoffers, P. (1991): Extraction of methane from seawater using ultrasonic vacuum degassing. Anal. Chem., 63 (5), 529-531.

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REPORT ON TASK 4.1 - 4.4

by P Linke, GEOMAR Kiel

In order to quantify the fluid and geochemical mass fluxes an existing device, the Benthic Barrel, was completely modified and integrated within a lander system (VEnt SPider = VESP) for TV-guided deployments from a surface vessel (Linke et al., in press). The Benthic Barrel, an open-bottom barrel with an exhaust port at the top, contains 5 sequentially activated water bottles and a CTD Probe. A thermistor flowmeter is emplaced within the exhaust and the flowrates are recorded by the CTD probe. Two flowmeters (one as a spare) were calibrated in the temperature range expected for the sample sites on cruise METEOR 26/2. The following figures (Fig. 15a-e) show the calibration plots of both flowmeters at different temperatures.

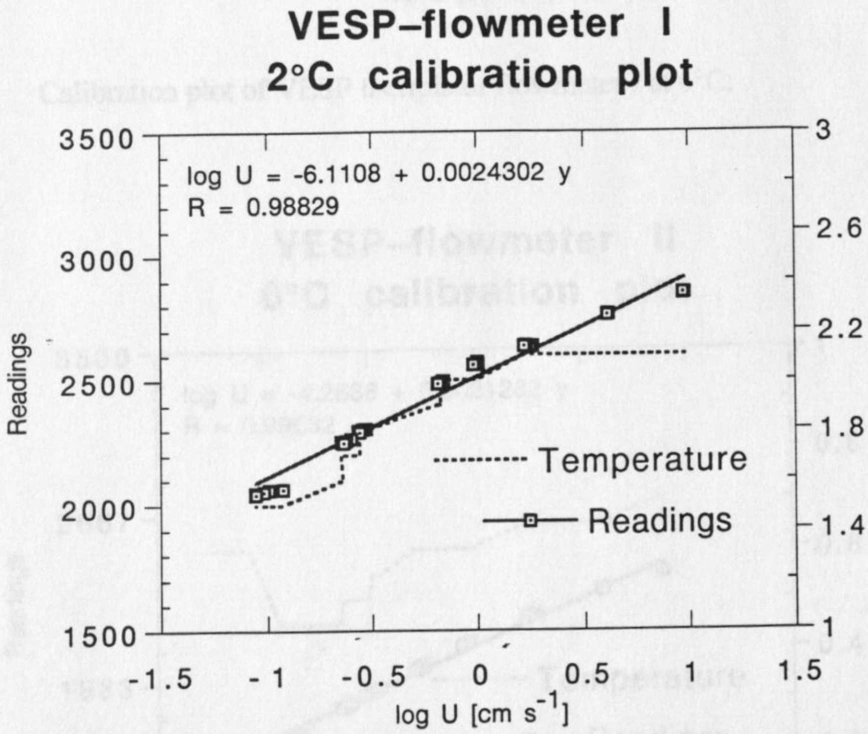

Fig. 15a: Calibration plot of VESP thermistor flowmeter I at 2°C.

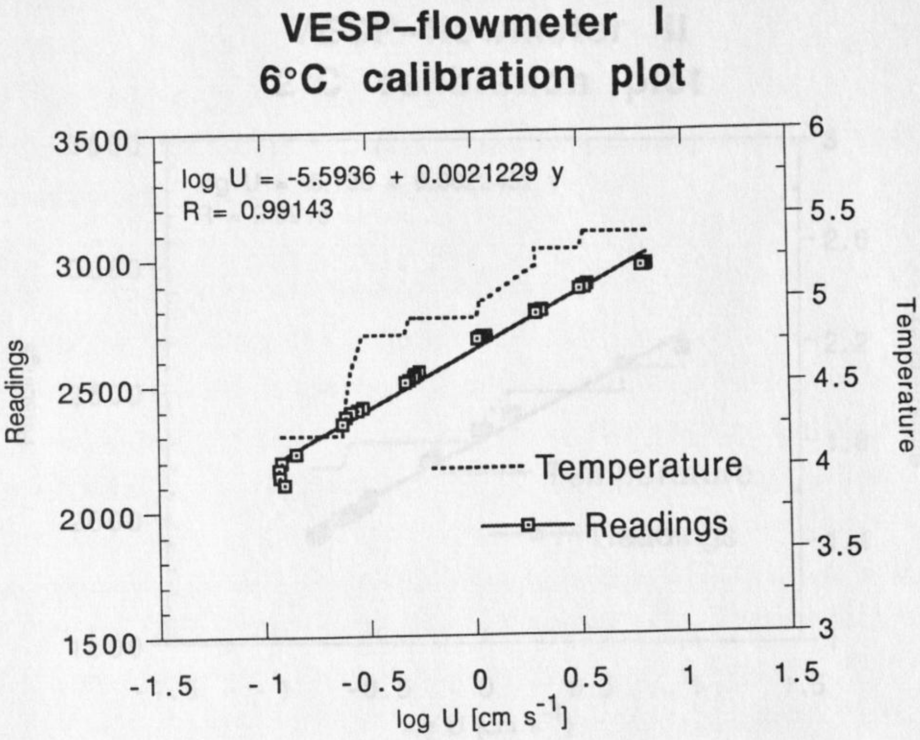

Fig. 15b: Calibration plot of VESP thermistor flowmeter I at 6°C.

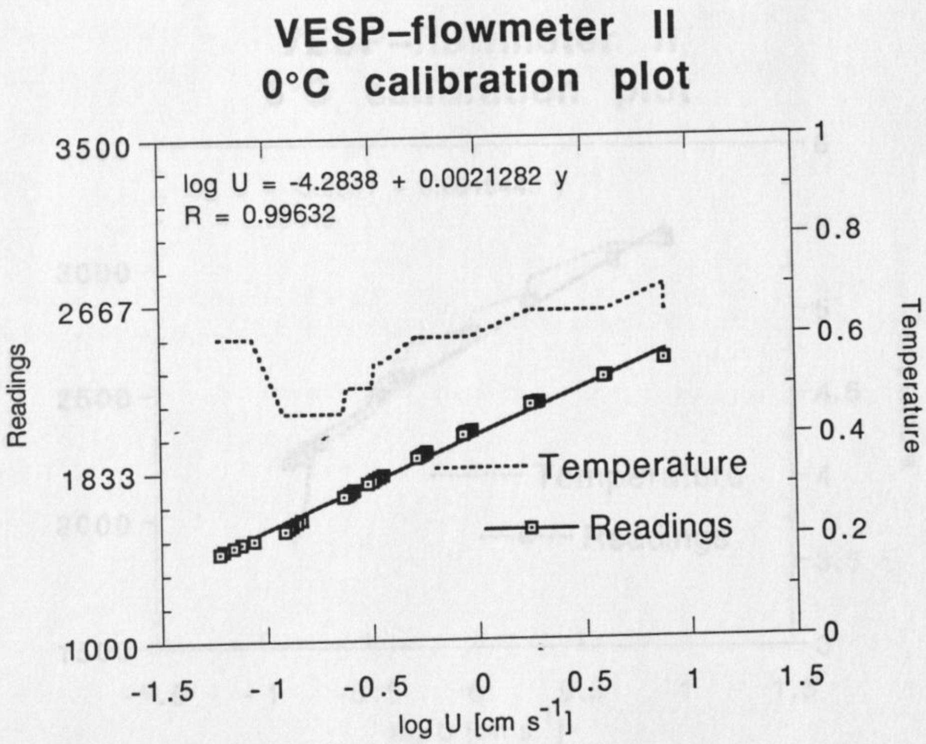

Fig. 15c: Calibration plot of VESP thermistor flowmeter II at 0°C.

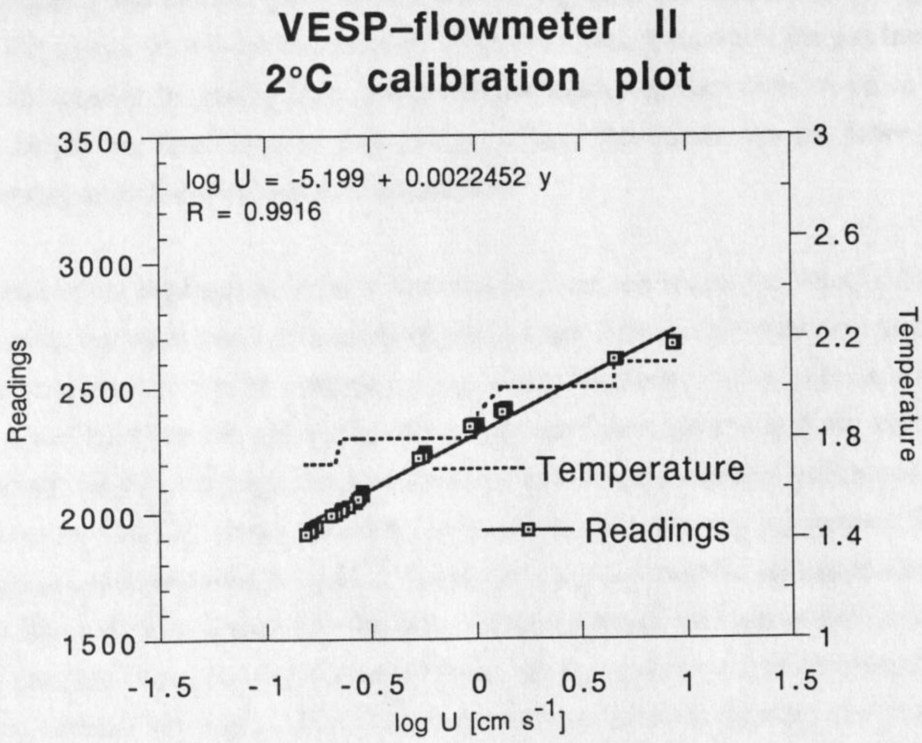

Fig. 15d: Calibration plot of VESP thermistor flowmeter II at 2°C.

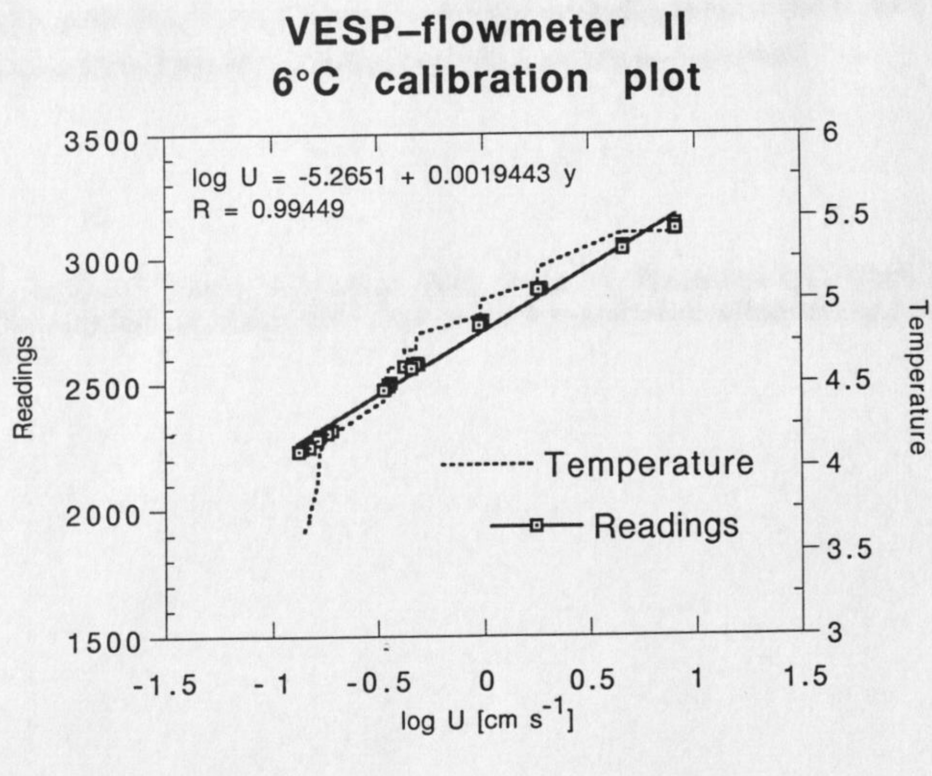

Fig. 15e: Calibration plot of VESP thermistor flowmeter II at 6°C.

In order to quantify and sample gas bubbles, emanating from the seeps, a gas detector was integrated in the barrel. This detector contains 10 sensors, which measure the gas level within the barrel by the change in conductivity, when the gas/water interface rises. A valve seals the exhaust port below the flowmeter to trap the gas within the barrel. An the other hand the flowmeter records an *in situ* baseline with no outflow.

For TV-guided remote deployment from a conventional surface vessel the barrel is lowered to the sea floor using the main frame of a modified multicorer. The barrel is attached to the central piston of the multicorer, which operates on a water hydraulic basis and assures gentle deployment of the barrel on the sediment surface once the frame has reached the sea floor. The frame is constructed from steel pipes connected by scaffolding clamps; additional diagonal pipes provide more stability, and a platform for mounting of accessory equipment. The frame carries a deep-sea photocamera, a flash, 2 floodlights, a videocamera and telemetry unit for bidirectional data and video transfer to the ship. All functions of the instrument (including the activation of the fluid and gas sampling) and its energy supply are controlled from the surface telemetry unit onboard the ship. CTD-, flowmeter and gas detector data are stored within the storage probe and are recovered after every deployment. In future these data will be directly transfered to the surface control unit.

The whole system was sucessfully tested prior to the METEOR cruise on a 2-day trip of the RV ALKOR in the Baltic Sea. Several dry runs and 3 survey deployments in the Barents Sea were performed during the METEOR cruise, but no active seep site was detected.

References:

Linke, P., E. Suess, M. Torres, V. Martens, W.D. Rugh, W. Ziebis and L.D. Kulm (in press): *In situ* measurement of fluid flow from cold seeps at active continental margins. Deep-Sea Res.

REPORT ON TASK 5.1

by P R Dando, PML Plymouth

Skagerrak

The gravity core 464-1 (Fig. 2) penetrated a seep area at the top of a 1.5 m high ridge. The presence of the seep was indicated by the strong hydrogen sulphide smell on opening the core, high methane concentrations near the surface of the core (>2 m moles dm^{-3} at 50 cm), high ammonia concentrations (up to 6.7 mM), the presence of adult and larval Pogonophores, *Siboglinum poseidoni* , and the presence of shells of the bivalve *Thyasira sarsi* at 30 and 35 cm depth. Pore water samples, obtained by filtration through alumina filters of 0.2 µm porosity, were additionally fixed for sulphate, dissolved sulphide, thiosulphate and sulphite analysis. Sediment was fixed for analysis of organic C & N, elemental sulphur, acid-labile and chromous reducible sulphur. Sulphate reduction rate incubations were carried out at 7°C on samples along the length of the core down to 5.05 m. Additional sulphate reduction-rate measurements were performed on bulked sediment from 38-42 cm depth and on sediment from 73-77 cm depth. This material was incubated in the presence and absence of added methane at 1 bar and 35 bar to investigate the effects of methane on the sulphate reduction rate.

The core was sliced in sections longitudinally immediately before sediment samples were taken for methane analysis. A methane maximum occurred at approximately 75 cm depth, a level just below the sediment surface reflector on the 5 KHz Parasound record. Methane concentrations decreased in an approximately linear manner from this maximum towards the sediment surface and also down core to a depth of 3.25 m. Below 4 m methane concentrations increased regularly with increasing depth. The results were interpreted to indicate a lateral flow of methane subsurface at approximately 0.75 m and diffusion of gas upwards and downwards from this point. Towards the base of the core methane increased again at a rate consistent with diffusion upwards from depth. The maximum methane concentration measured was 2.7 m moles dm^{-3} sediment. This would be an underestimate due to degassing during core recovery.

The ammonia concentrations were higher than had previously been recorded in this part of the Skagerrak and showed a double diffusion gradient with a change at 2 m depth, corresponding to the top of a hard reflector on the Parasound. This suggested a dilution of the upward diffusing ammonia at this depth.

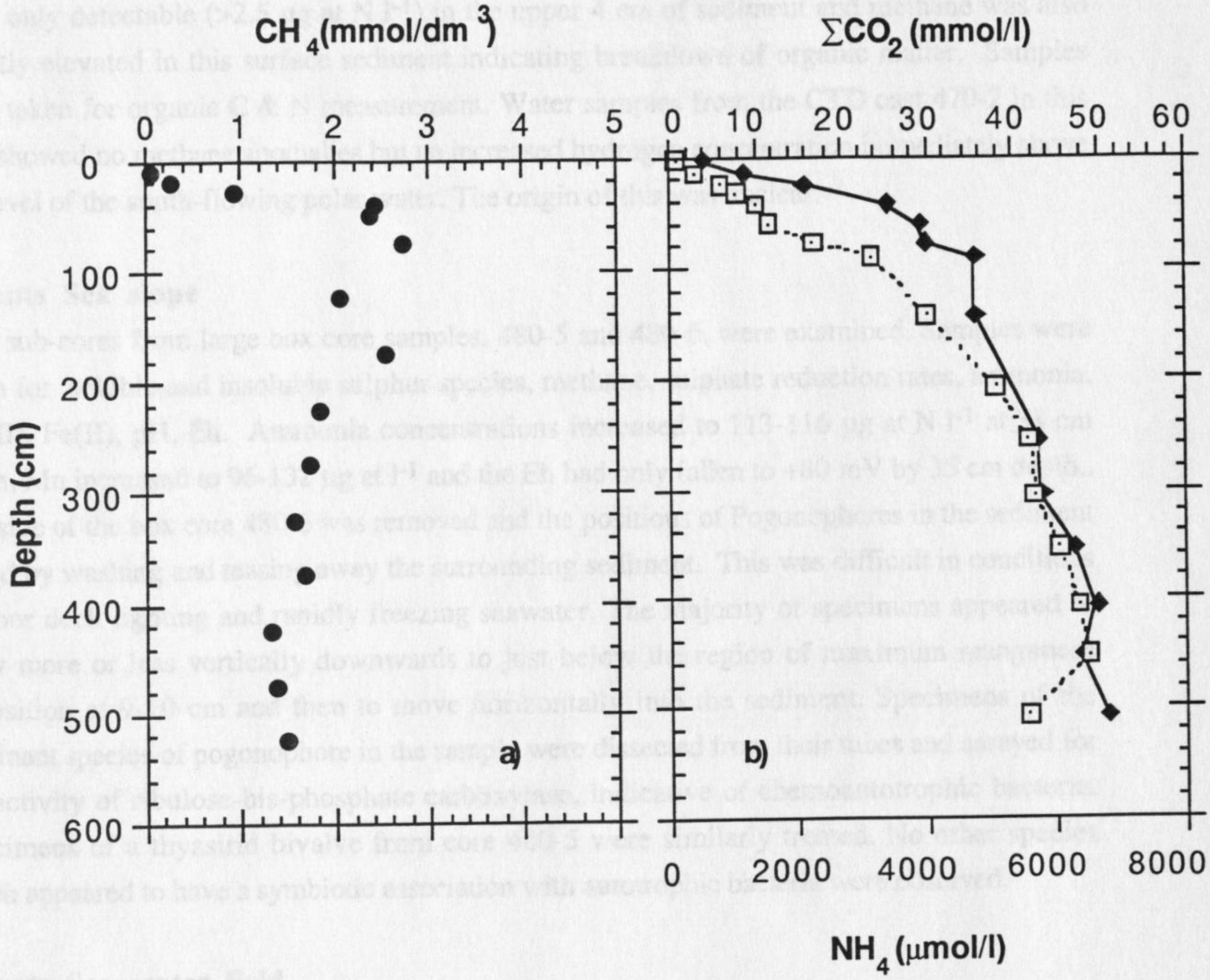

Fig. 16: Pore water profiles from gravity core 464-1 at the Skagerrak seep location
a) CH_4
b) ΣCO_2 and NH_4

No water column hydrogen anomalies were observed in CTD casts 463-2 and 467-1. The presence of very high methane concentrations, 1.8 µl l^{-1} water, in CTD cast 463-2 at 315 m was confirmed.

This core extends the line of seep cores collected, during 'CHALLENGER' cruise 82, 1.1 km to the SW and suggests that the seeps in the Skagerrak are linear features, probably running along the top of the low sediment ridges.

Faeroe-Shetland Channel

A multiple core sample, 474-1, was studied from this area. Samples were collected, down to a depth of 18 cm, for the determination of soluble and insoluble sulphur species as in the Skagerrak. Sulphate reduction rate measurements were also made. Ammonia concentrations were only detectable (>2.5 μg at N l^{-1}) in the upper 4 cm of sediment and methane was also slightly elevated in this surface sediment indicating breakdown of organic matter. Samples were taken for organic C & N measurement. Water samples from the CTD cast 470-2 in this area showed no methane anomalies but an increased hydrogen concentration immediately above the level of the south-flowing polar water. The origin of this was unclear.

Barents Sea slope

Two sub-cores from large box core samples, 480-5 and 480-6, were examined. Samples were taken for soluble and insoluble sulphur species, methane, sulphate reduction rates, ammonia, Mn(II), Fe(II), pH, Eh. Ammonia concentrations increased to 113-116 μg at N l^{-1} at 38 cm depth, Mn increased to 96-132 μg at l^{-1} and the Eh had only fallen to +80 mV by 35 cm depth.. The side of the box core 480-6 was removed and the positions of Pogonophores in the sediment traced by washing and teasing away the surrounding sediment. This was difficult in conditions of poor deck lighting and rapidly freezing seawater. The majority of specimens appeared to grow more or less vertically downwards to just below the region of maximum manganese deposition at 9-10 cm and then to move horizontally into the sediment. Specimens of the dominant species of pogonophore in the sample were dissected from their tubes and assayed for the activity of ribulose-bis-phosphate carboxylase, indicative of chemoautotrophic bacteria. Specimens of a thyasirid bivalve from core 480-5 were similarly treated. No other species which appeared to have a symbiotic association with autotrophic bacteria were observed.

Barents Sea crater field

Multiple core and sediment core sub-samples from box-cores were processed as previously. The first multiple corer taken, from 492-4, was approximately 15 cm deep but proved to have 2 large pieces of shale within it which had been pushed into the sediment, mixing the layers. Multiple core sample 496-8 and a 10 cm diameter sub-core from box core 496-3 were taken from a pockmark. The box core sample had a large piece of mudstone in the sediment and the subcore had numerous small pieces. The maximum ammonia concentrations observed at 35 cm depth were 40 μg at N l^{-1}. Evidence for methane seepage was only obtained for core 492-4, from the SE crater in the area surveyed (Fig. 17a). In this core methane concentrations reached 1 mmole dm^{-3} sediment at 10 cm depth. CTD station 492-2 over this crater was the only water sample set, analysed by the head-space method, to show increased methane in the bottom water (Fig. 17b). Multiple core samples 497-1 and 497-2 were taken from a sediment ridge on the seafloor outside the craters and samples were taken for comparison with the crater samples. The sediments inside and outside the pockmarks had similar Eh values down to 20 cm depth.

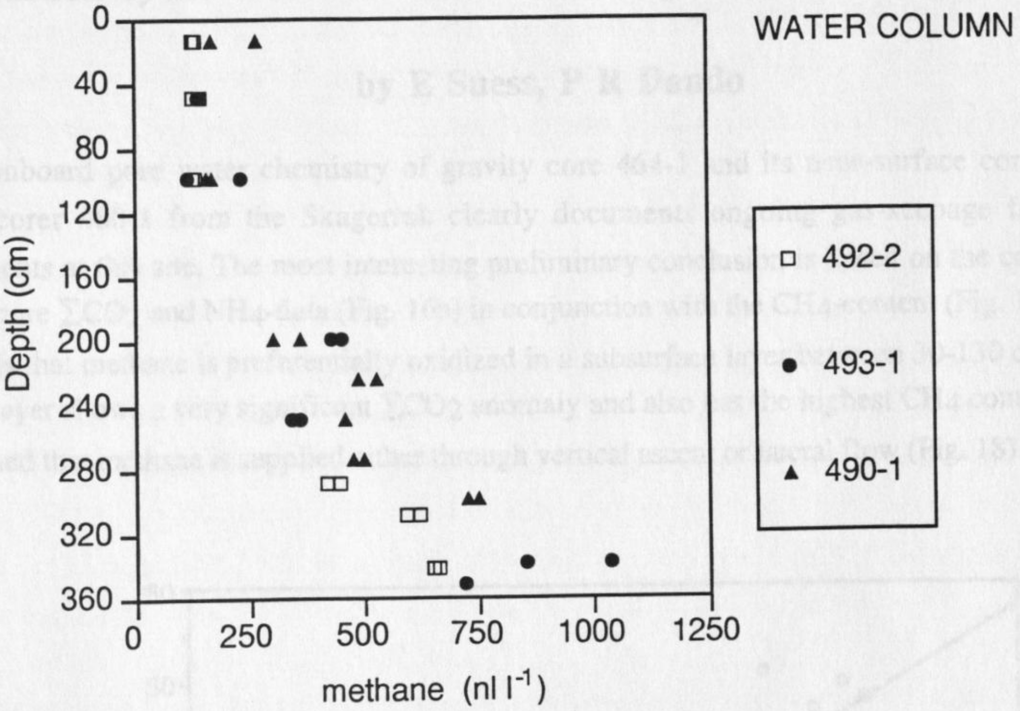

Fig. 17a: Methane profiles of water samples from the Barents Sea crater field showing elevated CH_4-contents in the bottom waters above the craters; these values were obtained by the head-space technique and give considerably higher results than the degassing technique; an intercalibration of both methods should resolve this dicrepancy.

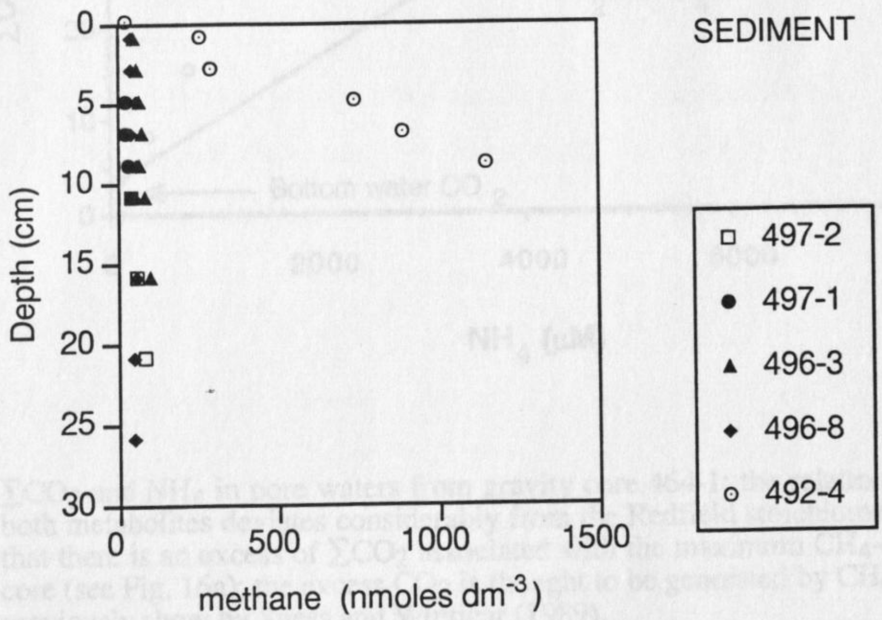

Fig. 17b: Methane contents of sediments samples from the Barents Sea crater field; only core 492-4 shows evidence for methane seepage.

REPORT ON TASK 5.3

Carbon cycle: Methane oxidation, ΣCO_2 and their isotopic criteria

by E Suess, P R Dando

The onboard pore water chemistry of gravity core 464-1 and its near-surface companion multicorer 460-1 from the Skagerrak clearly documents ongoing gas-seepage from the sediments at this site. The most interesting preliminary conclusion is based on the combined downcore ΣCO_2 and NH_4-data (Fig. 16a) in conjunction with the CH_4-content (Fig. 16b) and reveals that methane is preferentially oxidized in a subsurface layer between 30-130 cm deep. This layer shows a very significant ΣCO_2 anomaly and also has the highest CH_4 content. It is assumed that methane is supplied either through vertical ascent or lateral flow (Fig. 18).

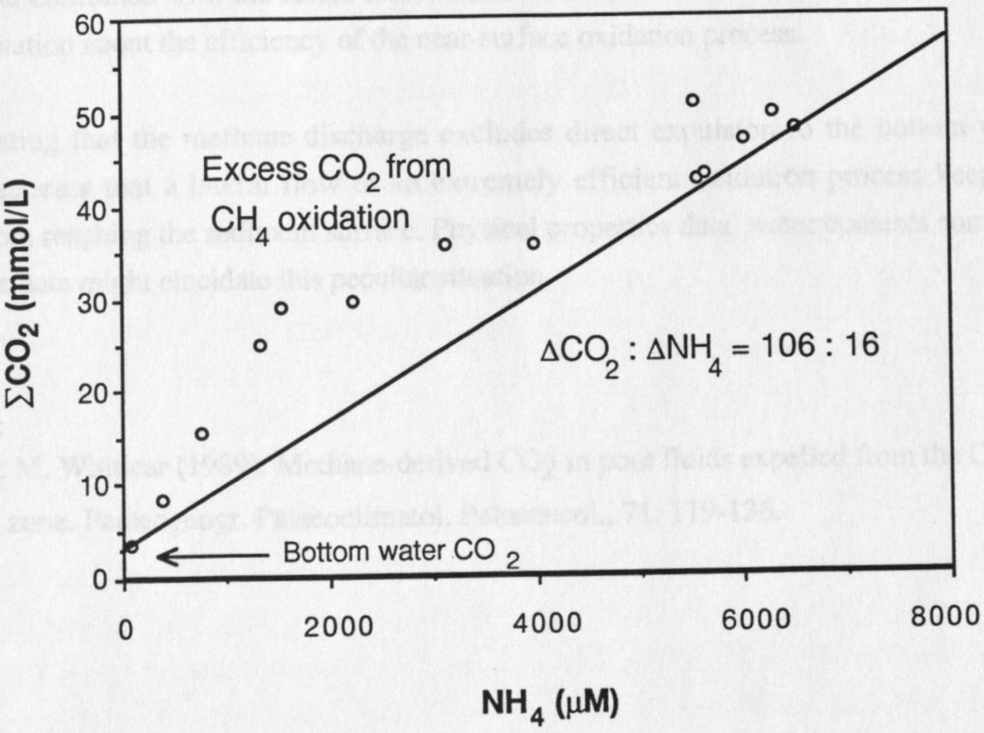

Fig. 18: ΣCO_2 and NH_4 in pore waters from gravity core 464-1; the relationship between both metabolites deviates considerably from the Redfield stoichiometry indicating that there is an excess of ΣCO_2 associated with the maximum CH_4-content in the core (see Fig. 16a); the excess CO_2 is thought to be generated by CH_4-oxidation as previously show by Suess and Whiticar (1989).

The argument that the excess $\sum CO_2$ is derived from methane oxidation and is not due to some random NH_4-fluctuations is illustrated in Fig. xxc. It shows that for the very surface and the deepest core sections the generation of $\sum CO_2$ and NH_4 proceed according to the Redfield ratio of marine organic matter decomposition; i.e. $\Delta CO_2 : \Delta NH_4 = 106 : 16$. However in the subsurface interval between 30-130 cm more $\sum CO_2$ is generated than would be expected from POC-decomposition. Hence another C-organic substrate must be oxidized but which does not release NH_4. CH_4 very likely is that substrate.

Other evidence to support this idea will come from stable isotope data of the dissolved $\sum CO_2$ and CH_4 from all core intervals as well as the dissolved sulfate contents (Suess and Whiticar, 1989). All precautions on sampling and preserving the labile gas phases for isotope analyses have been taken and the results should be available soon. The shipboard data also indicate that there is enough methane in the samples that they might yield sufficiently large amounts of carbon for ^{12}C-determination. Such data would be valuable in determining the source of the methane and combined with the stable isotope data of carbon and D/H of the methane might yield information about the efficiency of the near-surface oxidation process.

It is interesting that the methane discharge excludes direct expulsion to the bottom water. Instead it appears that a lateral flow or an extremely efficient oxidation process keeps the methane from reaching the sediment surface. Physical properties data, water contents combined with isotope data might elucidate this peculiar situation.

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REPORT ON TASK 6 - 6.2

by A. Tselepides, IMB Crete

Seep Macrofauna

Introduction - Objectives

Cold seeps are recognised as areas with high sulphide, ammonia and trace nutrient concentrations. They are also considered as areas of high benthic productivity due to a food web based on sulphur- and methane-oxidising bacteria. In studies conducted in deeper waters, chemosynthetic carbon fixation has been found to support dense and productive communities of benthic organisms that live near and around seeps.

The main objective of our study was to detect and study the chemosynthetic benthic communities that occur around relatively shallow seepage areas in the NE Atlantic European continental margin. In order to do so an extensive sampling programme was initiated in the known gas seep site in the Skagerrak, the slope on either side of the Faeroe-Shetland Channel, the Barents Sea slope and the Crater field area on the Barents Sea shelf. Despite the very difficult weather conditions that prevailed during most of the cruise (METEOR leg 26/2, 28.9-25.10.1993), a relatively large number (total of 18) of successful box-core samples were retrieved from all three target sites (Table 2). Unfortunately, due to technical difficulties and time constraints typical "seep samples" were not retrieved.

Field Work

Macrofaunal samples were taken with the use of a 0.25 m2 USNEL box core. Upon retrieval the material was sectioned into four depth layers (0-5, 5-10, 10-20 and 20-40 cm), sieved gently through a 500 um mesh, stained with Rose Bengal, preserved in 4% buffered formalin and stored in plastic jars for further laboratory analysis. Prior to this, each box core was subsampled for chloroplastic pigments (chl *a* and phaeopigments) and organic carbon. Redox potential measurements were undertaken by Dr. P. Dando when reducing conditions were evident. Sediment temperature was recorded at each station. Samples for meiofaunal and particle size analysis were taken by the group from the Univ. of Hamburg on the Barents Sea samples only.

Further laboratory analysis

The specific objectives of the analyses that will be undertaken in the laboratory are:

a. To determine the macrofaunal species composition, abundance, biomass and diversity in the various sampling sites.

b. To compare the above indices between the sampling sites.

c. To identify differences in species composition both along chemical and vertical gradients.

d. To analyse the macrofaunal data statistically and correlate it to the various environmental parameters.

Table 1 gives an overview of the stations that have been sampled as well the biological and chemical analyses that will be performed in the laboratory.

Station description

Skagerrak (Stations 460-468-469): Fine, soft, silt-clay sediment of gray colour. Below 20 cm depth the sediment texture became more compact. Sulphidic odour in the deeper layers indicated the existence of reducing conditions. Abundance of organisms observed at all depth layers. Many large Nereid and other sedentary Polychaetes were evident in the surface layers. Bivalves, Cumaceans, Amphipods, Sipunculids, Foraminifera, Asteroids and Echinoids were also observed. Actinians were very abundant in the video recordings. These samples were taken as near as possible to the seepage area and will therefore provide us with valuable background information concerning the macrobenthic community structure around these areas in the Skagerrak. It will also be interesting to see how they compare to the original seep samples retrieved during the MAST 1 project. Unfortunately two of the four box-core samples were destroyed due to the storm that we experienced on the the 14-15th of October 1993 in the Barents Sea.

Faeroe-Shetland Channel (Stations 474-475) : Coarse, residual sediment with abundant pebbles and rock fragments (lag deposit). Box core penetrated only to a depth of 20 cm. No indication of seepage was evident. Many sponge species were found attached to hard substrate surfaces and were collected by the representative of the Free University of Berlin (Dr. Peter Röpstorf). Ophiuroids, Polychaetes and Amphipods were abundant as well.

Barents Sea slope (Station 480): Fine, soft, silt-clay sediment of dark brown colour in the surface and gray below a depth of 10 cm. Many thin Pogonophores were found between 2-20 cm depth. Bivalves of the genus Thyasira were also found below 10 cm. Both of these species are considered to be characteristic of seep or high organic matter accumulation areas.

Polychaetes and Ophiuroids were also abundant. Despite the fact that this station showed promising indications of reducing or even seepage conditions, the extremely bad weather conditions in combination with the water depth (1600m) made it impossible to continue our sampling effort successfully. From the two box cores that were retrieved one was used for the macrofaunal analysis and sulphur chemistry, while the other was subsampled for meiofauna, organic and sulphur chemistry.

Barents Sea crater field and shelf (Stations 492-496-497): Fine, dark brown silt-clay sediment with shales on the surface, that gradually turned gray below 10 cm depth. Below 20 cm the sediment became very compact and sticky. No indication of active seepage was evident. Dense polychaete tubes were found throughout the various depth layers of the box-core. A high percentage of them (approx.60%) were found to be empty. Large and abundant Bivalves (Arca glacialis), Ophiuroids, Anemones and Pectinarid Polychaetes were evident as well. Few but large Cumaceans, Brachiopods, Asteroids and Holothurians were also collected in this area. Animal biomass seemed to be entirely dominated by the dense clusters of polychaetes that occurred within tubes. Station 497 was outside the Crater Field area, on the Barents shelf, and will therefore serve as a reference point. From our initial observations no qualitative difference was evident between this station and those in the craters (492 and 496). On the other hand, the latter probably support a higher animal biomass due to the organic matter that is trapped and accummulated within the crater.

Concluding remarks

Acquiring these samples was an extremely difficult and dangerous task if one takes into consideration the weather conditions that prevailed throughout this cruise. We should therefore be satisfied with the amount of work that did get done.

From the areas that were visited, the Skagerrak remains the most promising and accessible seepage site, while the Faeroe-Shetland channel should not be taken into consideration in the future. Work still remains to be done in the Barents Sea in order to locate the source that gives rise to the methane plume. The most complete series of biological samples were taken in this remote area and therefore our results, from a purely scientific point of view, are inherently valuable. If an active crater field is discovered in the future further north, then the work done during this expedition will serve as an ideal reference point.

Table 2: List of box corer stations taken for macrofaunal analysis:

	Sampling Area	GKG Stations	Depth (m)	Latitude	Longitude	Macrofauna Spec. comp. Abun.-Biom.	Chla	Pheo	CPE	OC	Temp. (°C)	Sed. Anal.	Meio-fauna
1	Skagerrak	460-4	320	58° 02.807 N	09° 39.092 E	Y	Y	Y	Y	Y	7,8	N	N
2	Skagerrak	468-2	337	58° 03.148 N	09° 39.506 E	N	Y	Y	Y	Y	7,3	N	N
3	Skagerrak	468-3	334	58° 03.146 N	09° 39.433 E	N	Y	Y	Y	Y			
4	Skagerrak	469-1	329	58° 02.583 N	09° 37.672 E	Y	Y	Y	Y	Y	0,2	N	N
5	Fa-Sh. Chan.	474-2	993	60° 26.024 N	04° 54.478 W	Y	Y	Y	Y	Y	0,9	N	N
6	Fa-Sh. Chan.	474-3	1012	60° 26.119 N	04° 54.598 W	Y	Y	Y	Y	Y			
7	Fa-Sh. Chan.	475-1	983	60° 23.859 N	04° 45.424 W	Y	Y	Y	Y	Y	0,7	N	N
8	Fa-Sh. Chan.	475-2	984	60° 23.695 N	04° 44.259 W	Y	Y	Y	Y	Y			
9	BS Slope	480-5	1601	74° 59.055 N	14° 22.032 E	Y	Y	Y	Y	Y	0,1		
10	BS Slope	480-6	1607	74° 59.025 N	14° 21.600 E	Y	Y	Y	Y	Y		Y	Y-GKG
11	BS Crat. Field	492-5	356	74° 54.228 N	27° 39.214 E	Y	Y	Y	Y	Y	< 0	Y	Y-MUC
12	BS Crat. Field	492-7	356	74° 54.269 N	27° 39.131 E	Y	Y	Y	Y	Y	< 0		
13	BS Crat. Field	492-8	358	74° 54.215 N	27° 39.200 E	Y	Y	Y	Y	Y	< 0		
14	BS Crat. Field	496-3	356	74° 55.434 N	27° 32.421 E	Y	Y	Y	Y	Y	< 0	Y	Y-MUC
15	BS Crat. Field	496-4	351	74° 55.506 N	27° 32.316 E	Y	Y	Y	Y	Y	< 0		
16	BS Crat. Field	496-5	349	74° 55.505 N	27° 32.201 E	Y	Y	Y	Y	Y	< 0		
17	BS Shelf	497-3	341	74° 55.785 N	27° 31.575 E	Y	Y	Y	Y	Y	< 0	Y	Y-MUC
18	BS Shelf	497-5	340	74° 55.852 N	27° 31.764 E	Y	Y	Y	Y	Y	< 0		

Fa-Sh = Faeroe-Shetland-Channel
BS = Barents Sea
Y=Yes
N=No
Chla = Chlorophyll a
Pheo = Phaeopigments
CPE = Chloroplastic equivalent
OC = Organic carbon

REPORT ON TASK 7 AND 7.1

by R Windoffer, I Gamenick, ZIM Hamburg

In order to look for structural adaptions of seep fauna at each putative vent station meiofauna samples were taken by boxcorer (GKG) or multicorer (MUC). To also obtain informations on meiofauna abundance and vertical distribution, the samples were fractioned into 0-1 cm, 1-3 cm, 3-5 cm and 5-10 cm layers and separately sieved through a 63 µm sieve. The remaining material including the fauna was then fixed with TRUMPS (glutaraldehyde and formaline in cacodylate buffer) for later quantitative analysis. The special tissue preservation feature of this fixative enables to use the animals also for ultrastructural investigations by electron microscope. The fixation allows also ultrastructural elemental analysis (EELS, ESI) of the material in order to look for possible accumulation of e.g. sulfur. At each station where quantitative meiofauna samples were taken, one subcore was taken for grain size analysis and sectioned into the same horizonts as described earlier. The salinity of the seawater above the sediment was determined using a refractometer.

Skagerrak

In the Skagerrak area a meiofauna sample from 0 to 2 cm was taken from the Multicorer (460-1). This sample did not hit a seep and was therefore of minor interest concerning the adaption topic. Still, we investigated the alive material in order to get an impression of the "non-seep meiofauna" community of this area.

From the gravity core that was taken very close to a seep (464-1) we got small meiofauna samples from 0 to 5 cm and from 8 to 10 cm sediment depth. In the upper sediment layer we found pogonophorans, few nematodes, two oligochaetes and turbellarians, while in the deeper sediment layer no animals occurred.

Faeroe-Shetland-Channel

In this area meiofauna samples were fixed from one MUC (474-1) and two GKG (474-4, 475-1). Since the sediment was not influenced by seepage and also contained large glacial rocks, only samples from the sediment surface (0-5 cm) were taken.

Barents Shelf slope

In the high accumulation area of the Barents slope five subcores (5 cm in diameter) were taken from GKG (480-6). Another subcore was taken for grain size analysis. This sampling site was of interest for us, because typical "vent fauna" like *Thyasira sp.* and pogonophorans were found. Besides the five quantitative samples, we fixed certain animals like nematodes, pogonophorans and their larvae and the gills of the bivalve *Thyasira sp* for electron microscopy.

Barents Sea crater field

Within the crater field two stations at the bottom of two craters and one "reference-station" outside a crater were sampled by MUC (492-4, 496-8, 497-1). For quantitative meiofauna analysis three cores (10 cm in diameter) were taken at each station, fractioned and treated as mentioned above. Further on subcores have been taken for grain size analysis at each station down to 15 cm sediment depth.

Since we have samples from two different craters and outside the craters, our data together with the quantitative macrofauna analysis of Dr. A. Tselepides and chemical data from Dr. P. Dando might give a first description of the community living in the Barents Sea crater field.

Of special interest are the samples from station 492-4, since high methane concentrations occur (data by Dr. P. Dando) in the sediment. This core from a seep allows us to analyse the meiofauna seep community as well as investigations on structural adaptations of the fauna to high methane and sulphide concentrations.

REPORT ON TASK 9 AND 10

by E Suess, GEOMAR KIEL

CRUISE REPORT AND OUTLINE OF MANUSCRIPTS

The R.V. METEOR cruise was the focus of the first year of the SEEP-contract. A planning meeting was held in Kiel prior to the cruise. The field work from 28 September - 25 October 1993 centered on four potential seep sites: the Skagerrak, the Faeroe-Shetland channel, the Barents Sea slope and the Barents Sea crater field. With the exception of the Faeroe-Shetland channel, all areas showed evidence for fluid and gas escape. Progress with the contract overall was good, although adverse weather conditions during the cruise prevented data acquisition to be truely excellent. The **cruise report** is completed and will be published in April 1994. In addition all partners have received a compendium of data collected during the cruise.

Work-up of cruise data and samples will be the focus for the second year of the contract. During the spring of 1994 a workshop is planned to exchange results and prepare outlines of manuscripts for publication. Tentatively, the seep site in the Skagerrak, located at and around the METEOR Station 464-1, should yield sufficiently interesting data to form the basis for one publication. The Barents Sea craters, their relationship to the bedrock structure, and dating of the "explosive event" should provide data for a second publication.

CRUISES AND SCHEDULE FOR FUTURE WORK

Several tasks which were not fully accomplished during the R.V. METEOR cruise will receive high priority during the second year of the contract. These include *in situ* sampling by VESP coupled with continuous flow measurements and a more complete collection of macro- and meio-fauna from a actively flowing seeps. For lack of adequate shipt-time and funds to mount another cruise entirely devoted to the SEEP-project in which all partners would participate, alternate ways of sampling will be pursued. One possibility is a location recently found in the western Baltic Sea off Eckernförde and located within an hour's steaming time from Geomar at Kiel. During one-day cruises in March and April VESP will be deployed there as well as a long-tern temperature probe installed. Preliminary results are encouraging and indicate that this seep is flowing continuosly and that low-saline waters (< 5 ‰ S) are being expelled. Methane and sulfide are concentrated in the fluids and their temperature appears to be slightly elevated.

This environment is suitable for accomplishing the tasks related to carbon and sulfur cycling. At present no evidence of macro- and meio-seep faunas has been found. However, additional sampling should reveal whether or not the biological tasks can be accomplished as well. A second possibility to accomplish the biological tasks is participation by partners as guests in other cruises scheduled to the Skagerrak seep area. Such plans are being pursued at the present time; they look promising.